PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

Engineering Library

JAN 27 1941

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VOL. 151—No. 3913. LONDON: FRIDAY, JANUARY 10, 1941. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 2½d.

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P. 6

THE DETERMINATION OF HYDROGEN-ION CONCENTRATION.

THE measurement of the *p*H value, or hydrogen-ion concentration, has long been established as a factor of definite significance in the majority of industrial manufacturing processes, but it is only of late that researches relating to the treatment and processing of metals have revealed many valuable applications for the determination of *p*H in the metallurgical field, and relatively little is generally known of the subject. It is therefore proposed here to describe briefly and succinctly something of the theory underlying the measurement and use of hydrogen-ion concentration, and to consider the significance of *p*H values in many metallurgical and associated processes. Reference will also be made to the apparatus employed for these measurements and to automatic control. If improved and uniform quality of product and economy of manufacture are to be attained, it is essential that in every possible avenue of production control the empirical practices employed too largely in the past shall be replaced by more accurate and scientific methods. Such conditions as temperature, pressure, and the like have long been subjects of careful and accurate measurement and control, but to these must now be added, in all processes which involve the use of solutions subject to chemical reaction, the necessity of determining and controlling the effective acidity or alkalinity of the solutions. This condition (as apart from the total or quantitative acidic or alkaline content) depends upon the concentration or activity of hydrogen ions in the solution, and in practice this is expressed numerically as its *p*H value.

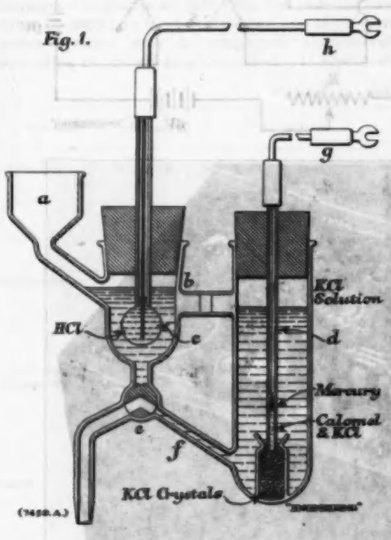
When a salt such as sodium chloride is dissolved in water, its molecules break down or dissociate into ions, each of which carries an electrical charge. The charge on every ion in solution, whatever its nature, has always the same value, or a simple multiple of this value, but metal ions carry a positive charge and non-metallic ions a negative charge. In any solution the total negative charge is equal to the total positive charge, as the bulk solution remains electrically neutral. All salts, acids and alkalis break down to a greater or lesser extent when dissolved in water. In the same way pure water itself is capable of breaking down into ions, these being hydrogen ions (H^+) carrying a positive charge and hydroxyl ions (OH^-) carrying a negative charge. The extent of dissociation in pure water is, however, extremely small, the concentration of the hydroxyl and hydrogen ions each being only 10^{-7} gramme-ions per litre. This means that, on the average, each litre of water contains only one ten-millionth of a gramme of hydrogen ions and an equal amount of hydroxyl ions.* The dissociation can be represented by the equilibrium :—

$$H_2O \rightleftharpoons H^+ + OH^-.$$

It is characteristic of a chemical equilibrium that, at a given temperature, the product of the concentrations of the components on one side bears a constant ratio to the product of the concentrations of the components on the other side. This is known as the Law of Mass Action. Thus, in any aqueous solution the product $(H^+) . (OH^-)$ is always 10^{-14}, and therefore, in order to define the concentration of either hydrogen ions or of hydroxyl ions in a solution it is necessary to know only one of these. Since it is much easier to measure the hydrogen ions than the hydroxyl ions, the acidity or alkalinity of a solution is expressed by the concentration of hydrogen ions. This concentration can change from 10, or more, in strongly acid solutions, to 10^{-14}, or less, in strongly alkaline solutions, and a less cumbersome method of expression has been devised. A concentration of, for example, 10^{-7} gramme ions per litre could be expressed as -7. In practice, the negative sign is omitted and the conventional expression becomes 7. This is called the *p*H value ; thus a *p*H of 2 means 10^{-2} gramme ions of hydrogen ions and 10^{-12} gramme ions of hydroxyl ions per litre. Mathematically, the *p*H value is the same as $\log_{10} \frac{1}{(H^+)}$. It is useful to relate *p*H values to the usual chemical system of expressing the strengths of solutions by normality. When an acid is completely dissociated in solution, a tenth normal solution (expressed as N/10 or 10^{-1} N) would have a *p*H of 1, a hundredth normal solution (N/100 or 10^{-2} N) a *p*H of 2, and so on. A tenth normal solution of alkali would have a hydroxyl-ion concentration of 10^{-1} and, therefore, a hydrogen concentration of 10^{-13} and a *p*H of 13. It should be remembered, however, that acid solutions may not be completely dissociated, in which case the above statement does not hold ; the *p*H value represents only the effective acidity, that is, the concentration of dissociated hydrogen ions, and not the total acidity, which may include ionisable hydrogen present in undissociated molecular combination. The property of a solution called acidity is thus associated with an excess of hydrogen ions, and alkalinity with an excess of hydroxyl ions. Consequently, *p*H expresses the effective acidity or alkalinity of a solution in a quantitative and accurately measurable manner. A neutral solution, such as distilled water, is one in which hydrogen and hydroxyl ions are present in equal numbers ; that is, the *p*H is 7. Lower *p*H values represent acid solutions, and higher *p*H values alkaline solutions.

Certain solutions, which consist fundamentally of mixtures of an alkali or weak acid with one of its salts, have the property that they are able to resist changes in hydrogen-ion concentration. For example, if a small quantity of hydrochloric acid be added to a solution of sodium chloride, the hydrogen-ion concentration of the solution will be changed by the amount of hydrogen ions added, as no reaction takes place. If, however, the same quantity of hydrochloric acid be added to a solution containing sodium acetate and acetic acid, the hydrochloric acid reacts with some of the sodium acetate to give sodium chloride and acetic acid, which furnishes a much smaller number of hydrogen ions, so that the change in hydrogen-ion concentration is much less. The mixture of sodium acetate and acetic acid is therefore said to act as a buffer solution. If, instead of adding acid or alkali, an attempt be made to change the hydrogen-ion concentration by dilution, the effect will be much less than on a solution of a "strong" acid. An equal volume of water added to a solution of hydrochloric acid will reduce the hydrogen-ion concentration to approximately half, while if a sodium acetate-acetic acid solution be diluted to half strength, the concentration of acetate-ion and acetic-acid molecules will each be approximately halved, so that the hydrogen-ion concentration will remain practically unaffected. Such buffer solutions, on account of their stability, are used for control and standardisation purposes and are referred to later.

From the foregoing it will be seen that the properties of a solution, vaguely described by the terms acid, neutral, or alkaline, can be expressed quantitatively by the single term, hydrogen-ion concen-



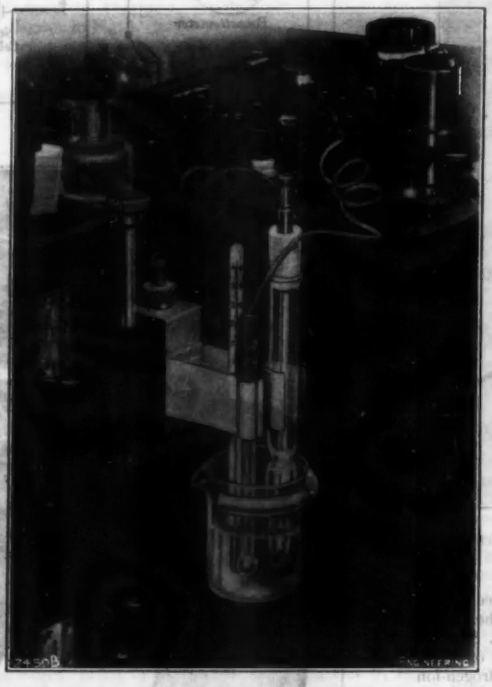
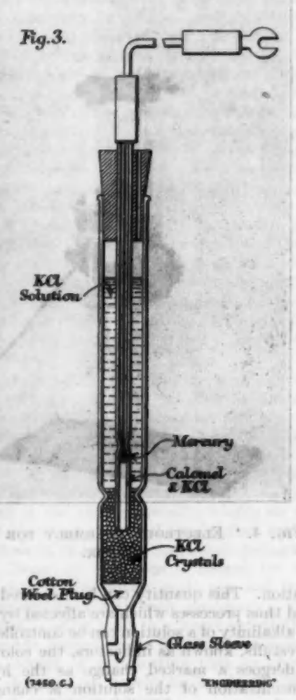


FIG. 2. GLASS ELECTRODE ASSEMBLY.



* The standard method of expressing concentration of ions in a solution is the formula weight of the ions in grammes per litre of solution. Thus, a unit concentration of hydrogen ions is 1 gramme per litre ; of hydroxyl ions, 17 grammes per litre ; and of sodium ions, 23 grammes per litre.

MEASUREMENT OF HYDROGEN-ION CONCENTRATION.

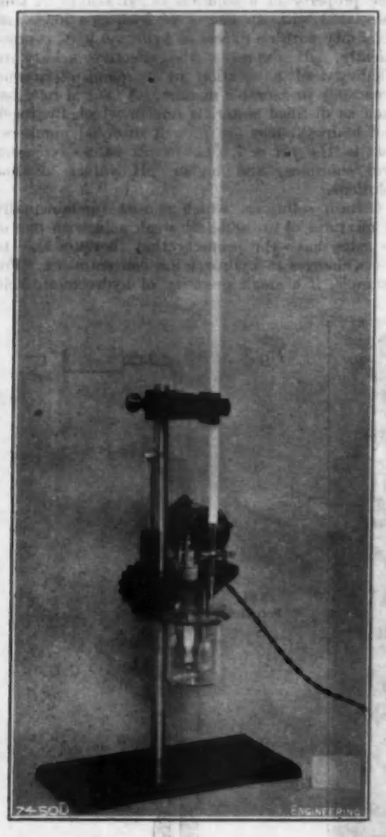
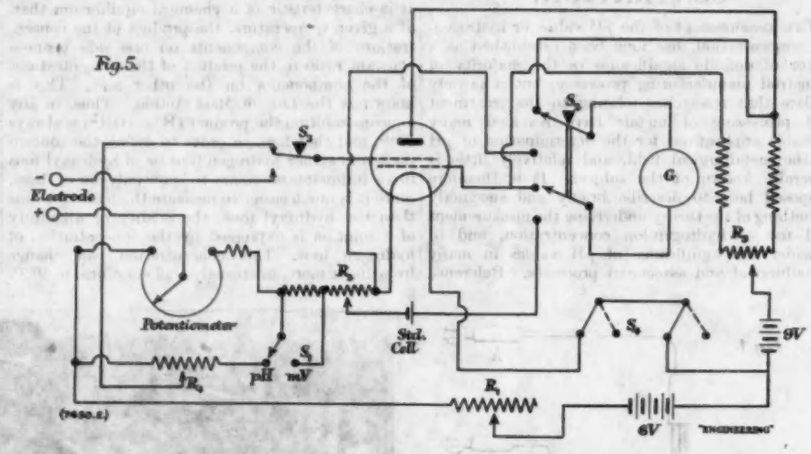


FIG. 4. ELECTRODE ASSEMBLY FOR TITRATION WORK.



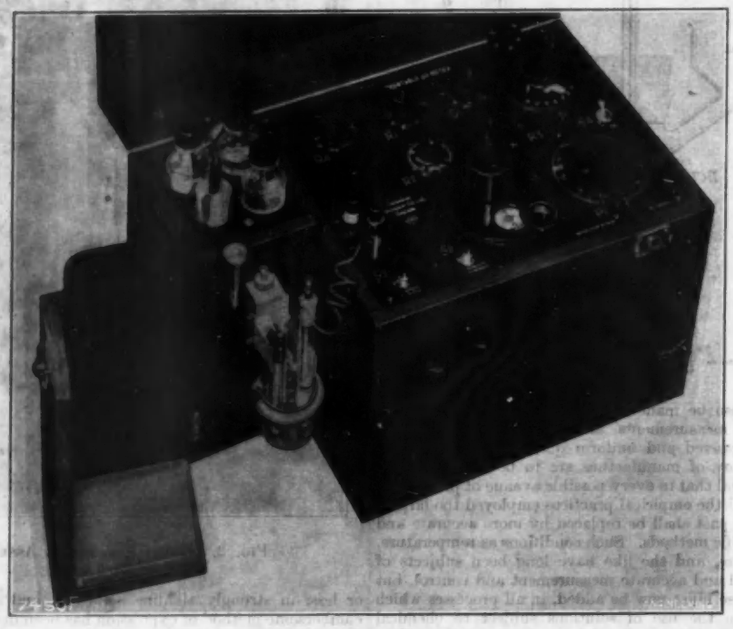


FIG. 6. CAMBRIDGE PORTABLE *p*H METER.

tration. This quantity can be measured accurately, and thus processes which are affected by the acidity or alkalinity of a solution can be controlled. Suitable dyestuffs, known as indicators, the colour of which undergoes a marked change as the hydrogen-ion concentration of the solution is changed over a small range, may be used for indicating the condition approximately, but accurate measurements can only be made by determining the potential developed between the solution and a suitable electrode by virtue of the electric charge of the ions in solution. This electrical potential bears a definite relation to the *p*H of the solution. Electrodes of various types can be used not only for ordinary solutions, but also for viscous liquids and pastes. The potential is measured on specially designed direct-reading or recording potentiometers, of which details are given below. The standard electrode, to which all others are referred, is the hydrogen electrode. This can be of various forms, the most usual consisting of a platinum plate, coated with platinum black, round which hydrogen gas is bubbled. In order to measure an electrode potential, it is necessary to complete the electrical circuit by a second connection to the solution. This cannot be done by simply dipping a wire in the solution, as an unknown and variable potential would be set up at the surface of contact. The second electrode must be one of which the potential with respect to the solution does not vary with the *p*H of the solution or with the concentration of other substances present. Many such electrodes are available, but the most usual is the one known as the saturated calomel electrode, consisting of mercury in contact with saturated potassium chloride solution, which is also saturated with calomel (mercurous chloride). The contact with the test solution is made by the potassium chloride solution as this does not set up a contact potential. Such an electrode is similar to a standard cell and gives a constant potential.

The potential E_H, in volts, between the hydrogen electrode and a solution, has the following relation to the *p*H of the solution at a temperature *t* deg. C.

$$E_H = -0{\cdot}0001984\ (273 + t) \times pH.$$

Roughly, if *t* is 20 deg. C., a change of 1 *p*H in the solution will alter the potential by 58 millivolts. The inclusion of temperature in the equation is due to the fact that variations in temperature have a considerable effect upon the ionisation of solutions, and therefore upon the *p*H. In modern direct-reading apparatus for electrometric *p*H measurements, provision is made whereby the temperature effect is compensated. The hydrogen electrode, unfortunately, is very sensitive to the presence of certain substances, such as oxidising agents, alkaloids, proteins and ammonia. These cause a progressive drift of the potential, generally towards a positive value. The phenomenon is described as "poisoning." The hydrogen electrode, however, in the absence of poisons, will give accurate readings over the whole *p*H range. Other forms of electrodes, such as antimony and quinhydrone, are widely used in industry, but the type that is of principal interest is the glass electrode. This has advantages over other electrode systems for many purposes, and its introduction has greatly widened the scope of *p*H measurement in industry. Owing to the high electrical resistance of the glass electrode, a modified form of potentiometer, incorporating a thermionic valve, is employed. While the glass electrode cannot conveniently be used in association with an ordinary potentiometer, the special forms of potentiometer designed for the glass electrode can be employed equally well with electrodes of other types. The present tendency, therefore, is to standardise on the thermionic-valve potentiometer for routine *p*H measurements.

The glass electrode owes its action to the fact that, when a thin glass membrane separates two solutions, an electrical potential, which varies in relation to the *p*H difference of the solutions, is set up across the membrane. The *p*H/e.m.f. relationship is practically linear up to *p*H = 10, and the glass electrode can also be used above this figure if standardised on a buffer solution of which the *p*H value is near to that of the solution to be measured. Various designs of electrodes have been

made for special applications, but the most useful for general work consists of a bulb of special glass filled with buffer solution, which is simply placed in a beaker, or similar vessel, containing the solution under test, and accommodating also a calomel electrode. The choice of electrode is a consideration of major importance in dealing with any particular application of electrometric measurements.* The principal factor in this choice is the range of *p*H values which it is desired to measure, while further factors are the accuracy required to ensure adequate readings, and the character of the solutions employed. In Table I,* the more usual electrodes are tabulated, showing the *p*H range over which they are most satisfactory, their relative advantages and limitations, and some applications.

The special characteristics of these electrodes and the accuracy of readings obtainable have also been described elsewhere.† As a rough guide, it may be stated that, where vigorous oxidising or reducing conditions are met with, the glass electrode must be used; in most other cases, one of the three other systems may be employed alternatively, according to the *p*H range required. It is proposed here only to discuss the glass-electrode system, which, owing to its particular characteristics and the improved robustness in construction recently attained, is finding increasing use in industrial applications. Colloidal matter and oxidising agents, such as free chlorine and hypochlorites, do not affect the glass electrode, while, on the other hand, the electrode is not likely to affect the material with which it comes in contact. One form of glass-electrode system, due to C. Morton, is shown diagrammatically in Fig. 1, on page 21. The liquid of which the *p*H value is to be determined, is introduced through the receiver *a* into a vessel *b*, thus immersing the sealed glass electrode *c*. Liquid connection with the calomel cell *d* is established by the stop-cock *e* through the connecting tube *f*. Connections to the potentiometer are made from the terminals *g* and *h*. Another convenient and compact form of glass electrode system is illustrated in Fig. 2, on page 21; in the illustration, a beaker is provided to contain the solution to be tested. The dip-type calomel cell is shown in Fig. 3, also on page 21. This cell contains the usual connecting solution of saturated potassium chloride, and is provided with a ground and tapered glass sleeve at the base, arranged to cover a small vent hole, through which the liquid junction is obtained; it is shown immersed, together with the glass electrode, in the solution under test in Fig. 2. A further electrode system, shown in Fig. 4, opposite, is intended for use when it is desired not only to obtain qualitative but also quantitative determinations of the constituents of certain solutions. A burette mounted over a beaker is filled with a known titrating solution which is allowed to pass into the beaker by means of a stopcock, the *p*H value of the solution in the beaker being measured at each addition of the titrating solution. By plotting the change of *p*H against the quantity of solution added from the burette, it is possible to obtain quantitative measurements by calculation. A motor, suitable for operation from standard electric mains, drives a stirrer which serves to agitate the liquid in the beaker. The outfit shown is fitted with standard glass and dip-type calomel electrodes.

A diagram showing the wiring system of a typical form of measuring instrument for use with the electrodes described is shown in Fig. 5, opposite. This circuit, suggested by Mr. C. Morton, provides a direct reading in *p*H units and is incorporated in the portable instrument made by Messrs. The Cambridge Instrument Company, Limited, shown below the diagram in Fig. 6. Referring to Fig. 5, the electrode system is connected to the terminals shown on the left of the diagram, and is brought into circuit by depressing the key S_3. The switch S_1 enables the instrument to be used to give direct readings, either in *p*H units or in millivolts; switch S_2 connects in circuit a standardising cell, and S_4 is the battery switch. Of the various resistances incorporated R_1 serves to adjust the battery circuit for any variations in battery voltage, R_2 balances the anode current, while R_4 is a reference rheostat which obviates the need for frequent checks against a buffer solution, and enables possible variations in the characteristics of the thermionic valve to be readily checked and, if necessary, compensated during a series of tests. R_3 is a temperature-adjustment rheostat, the dial of which is calibrated to read in temperature degrees, and is set to compensate for the variations in *p*H which occur at different temperatures. An external view of the potentiometer is shown in Fig. 6. This instrument exemplifies the modern tendency to compactness of design in scientific instruments. The whole outfit, comprising the potentiometer, electrode system, buffer solution and spare electrodes, is self-contained and is incorporated in a case measuring only 16 in. by 10 in. by 12 in. The necessary batterics are also self-contained in a removable drawer in the base. The potentiometer is calibrated for a range of 0 to 14 *p*H units, each division on the circular dial corresponding to 0·02 *p*H. As already explained, the simple range switch S_1 enables readings in millivolts to be obtained, the range being 0 to 1,400 millivolts; readings are given directly to 2 mV, or by estimation to 1 mV. This type of potentiometer is also available as a bench *p*H meter without a self-contained electrode system, for use when it is desired to build up the assembly from separate components.

(To be continued.)

TABLE I.—ELECTRODE COMPARISONS.

Electrode	*p*H Range.	Advantages.	Limitations.	Applications
Hydrogen ..	0 to 14	Basis and standard of *p*H measurement. Covers entire *p*H range. Not subject to salt error. Can be used in coloured and turbid solutions. Has low electrical resistance.	Requires Pt catalytic surface and supply of pure hydrogen gas. Pt surface susceptible to "poisons." Cannot be used in solutions containing dissolved gas. Not good for use in unbuffered solutions, especially between 5 and 8·5 *p*H.	Research Lab. Calibration of buffer and colorimetric standards. Biochemical investigations. Absolute standard of *p*H measurements.
Quinhydrone ..	0 to 9	Does not require a catalytic surface or gas. May be used in solutions containing dissolved gases. Simple in operation and relatively economical.	Cannot be used in presence of most oxidising and reducing substances. Cannot be used in presence of sulphites, chromic acid and ferric salts. Samples become contaminated with quinhydrone.	Research Lab. Nickel plating. Fermentation processes. Water purification. Biological investigations. Dairy industry.
Antimony ..	4 to 11	Rugged and durable. Can be used in semi-solids, sludges and viscous solutions. Has low resistance. May be used in presence of acetates, sugar, soap, suspensions, clay, alum, lime, etc.	Calibration not same in static and flowing liquids. Subject to "poisoning" by even traces of Cu and Ag. Slightly soluble in acid solutions. Subject to error in oxydising and reducing solutions.	Sugar refineries. Paper mills. Water purification. Coagulation, neutralisation and recarbonation processes. Corrosion prevention.
Glass	0 to 14	No contamination of sample. Can be used in presence of oxidising and reducing substances. Can be used in unbuffered solutions. Not subject to "poisoning." Can be used in presence of dissolved gases.	Subject to alkaline salt error over 9 *p*H. Subject to salt error above 2N. High-resistance system requiring amplification. Some types subject to breakage.	Research Lab. General industrial applications. Tanning industry. Water treatment. Sewage treatment.

* Report on Measurement and Control of *p*H, *Chem. & Met. Engineering*, Series A, No. 5, page 554 (August, 1940).

† See A. D. E. Lauchlan, "Electrical Control of Chemical Processes," *Proc. Chem. Eng. Group*, vol. 18, page 87 (1936).

AMERICAN MARINE DIESEL ENGINE DEVELOPMENT.

WHEN, in 1937, the United States Maritime Commission was formed, and laid down a general policy for the building of 500 mercantile ships within ten years, the American shipbuilding and marine engineering industry had fallen to a very low ebb. No ocean-going cargo or passenger ships of any importance had been built for many years, so that the problem of building the machinery for the large number of ships contemplated was one of some magnitude. Up to the present time, the Commission has ordered 179 ships, of 1,441,673 tons gross, and of these 51 have been delivered. In addition, private owners have ordered a considerable number of tankers, but the Maritime Commission is responsible for practically the whole of the cargo and passenger tonnage that is likely to be built in the United States for some years. With such a large programme of construction, it is natural that careful investigation should be made on the subject of standardisation of machinery, in view of the fact that the ships were mainly limited to three classes, requiring a total engine power of 4,000 shaft horse-power, 6,000 shaft horse-power, and 8,500 shaft horse-power, respectively. As a result of the study which was made, two fundamental arrangements were adopted, namely, oil-fired boilers and cross-compound geared turbines, and Diesel plant utilising, in one case, a direct-connected engine, and, in others, geared machinery. In all, 42 motor ships have been ordered (11 being completed) and there is no doubt that, had there been larger manufacturing facilities for marine oil engines, the number would have been greatly increased, bearing in mind that America is the largest oil-producing country and that liquid fuel is to be used in all cases, to the entire exclusion of coal.

Owing to the small number of orders placed before the year 1937, however, the capacity to produce large marine oil engines was naturally limited. As a result, there are very few manufacturers who have such marine experience, and the whole of the machinery for the 42 motor ships in question is being supplied by only four concerns, of which three have concentrated in the past practically wholly on the building of stationary internal-combustion machinery. The fourth, Messrs. The Sun Shipbuilding and Dry Dock Company, took out a licence for the British Doxford engine many years ago and built several ships equipped with such machinery. This type of engine is being built to a larger extent than any other in the United States for the new tonnage, and it is a source of gratification that an engine of British design and development should have achieved such success in America.

For a long time, American engineers have favoured the indirect drive, and more than two-thirds of the motor ships recently built or now building have relatively high-speed engines driving the propeller through reduction gearing. This policy has a special significance to shipbuilders and marine engineers in the United Kingdom, since geared propulsion in conjunction with Diesel engines has never been received with favour in this country, and, in fact, there is no large British vessel so equipped. It is held in the United States, however, that the arrangement is advantageous on account of the smaller space occupied by the machinery, and the lower weight. Possibly another factor which influenced the decision is that several of the engines adopted for marine propulsion were based upon stationary, relatively fast-running, designs already developed by the manufacturers. It is specially noteworthy, however, that several of the ships with Sun-Doxford engines will be fitted with the indirect geared drive, despite the fact that such a system has not been employed in this country in any of the large number of Doxford-engined vessels now in service. In the American geared motor ships, two systems of transmission have been standardised. In one case, hydraulic couplings are fitted between the engines and gearing, and in the other, electric slip couplings are employed—a method which has been gaining ground in Scandinavia during the pre-war years, but in which no interest has been shown in this country. It is a fundamental policy of the

United States Maritime Commission that all their vessels shall be of the single-screw type, and in some of them two engines are coupled to the propeller through gearing, while, in the larger and higher-powered ships, four similar engines drive a single propeller.

Another condition laid down by the engineers of the United States Shipping Board was that the main and auxiliary machinery of all of the motor ships should operate on a relatively heavy grade of residual oil, substantially cheaper than the Diesel fuel which is normally employed in motor vessels. It is a high-grade of "Bunker C," costing on an average between 20 per cent. to 30 per cent. more than normal boiler oil. It has a specific gravity of about 0·96 to 0·97, a flash point of 180 deg. F., and a viscosity of between 200 and 300 Redwood No. 1. A good deal of experimental work was carried on with a view to ensuring that the engines would operate satisfactorily on this fuel, and certain modifications were made to the normal fuel-injection pumps and valves. Moreover, in all ships the oil is first heated to 180 deg. F., then passed through centrifugal purifiers and reheated to a similar temperature, at which it is delivered to the fuel pumps. The fuel consumption appears to be somewhat higher than when using the normal Diesel oil, and it is stated that, in the first of the Sun-Doxford Diesel-engined ships, an overall consumption was attained of 0·401 lb. per shaft horse-power per hour for all purposes. It is probable also that the liner wear will be greater than the normal, and, in order to limit this, experiments are being carried out with the use of chrome-hardened liners.

The Sun-Doxford opposed-piston engines for directly-propelled ships, illustrated in Figs. 1, 2 and 3, on Plates II and III, are similar in most respects to the type built in this country, but the cylinder dimensions are larger and the specific cylinder output greater than in any British Doxford machinery. The standard design, of which about 20 units are being built, has four cylinders with a diameter of 32 in. and with upper and lower piston strokes of 55 in. and 40 in., respectively, or a combined stroke of 95 in. The rated output of the engine is 6,000 brake horse-power at 92 r.p.m., with an overload rating of 7,500 brake horse-power at 100 r.p.m., or 1,835 brake horse-power per cylinder. The normal Doxford electrically-welded steel framework construction is employed, the bedplate being also of welded steel plate with cross members for the reception of the spherical cast-iron main bearings. On the top of the A frames is the entablature, built up of steel plate in two sections, which are bolted together. The crankshaft is of the built-up type, of forged steel. Distilled water is used for cooling the cylinders and pistons, and flexible rubber tubing is fitted for the inlet and discharge connections to the upper and lower pistons. This is a system which was developed by Messrs. Doxford some years ago and has been standardised ever since. There are two symmetrically-placed horizontal fuel valves in the centre of the cylinder, actuated, respectively, by front and back camshafts, both of which are arranged with a vertical drive from the crankshaft at the after end of the engine. The front camshaft is provided with ahead and astern cams and the back camshaft with ahead cams only.

The main point of difference between the Sun-Doxford engine and that developed by the British designers was in the employment of two rotary scavenge blowers driven by chain from the crankshaft, instead of the normal piston-type scavenge pump. The blowers have a capacity of 13,000 cub. ft. per minute, but it was stated recently that, after experience in service, it was decided to modify this arrangement and to supply the scavenging air from separate electrically-driven blowers. The crowns of the pistons are concave, so that the compression space is approximately spherical, and into this space the fuel is injected in conical sprays through a circle of small holes in the fuel nozzles. A two-part piston is adopted, and in each piston head are five rings.

In addition to the engines of the slow-running type, which are built for installation in direct-driven ships, the Sun Shipbuilding and Dry Dock Company is manufacturing a number of Doxford-type engines for indirect propulsion. They are four-cylinder units running at 180 r.p.m., and two in each ship will drive a single propeller at a speed of 79 r.p.m., electromagnetic slip couplings being used. As already stated, no Doxford geared installation has yet been built, so that the experiment, if it may be so termed, is of some significance, especially as the officers of the United States Maritime Commission will be able to make comparisons between the geared system and the direct drive. The engines are designed to develop 4,500 brake horse-power, with a 25 per cent. overload capacity, the output being then 5,650 shaft horse-power at 195 r.p.m. A two-pinion single-reduction gear is fitted, the reduction gear assembly containing a thrust bearing integral with it.

One of the results of the adoption of the gear drive in most of the Maritime Commission ships is that engines, standard in every respect, can be installed in vessels requiring widely different machinery powers. In some of the larger (C 3) cargo ships, an output of 8,500 brake horse-power is needed and, in the smaller vessels, about 4,000 brake horse-power. For many of these the Busch-Sulzer engine has been adopted, the one type, rated at 2,250 brake horse-power per engine, being used. As a result, orders for over 30 engines of this class have been placed and the advantage from the standpoint of works production is substantial. Incidentally, it should be added that the engines are not of Sulzer design for, although the builders originally manufactured to Sulzer licence, the present unit is of their own design. The 2,250-brake horse-power engine, illustrated in Figs. 5 and 6, on page 30, is of the two-stroke, trunk-piston, single-acting type, running at 240 r.p.m. and having seven cylinders with a diameter of 520 mm., the piston stroke being 700 mm. As the output of the machinery in the C1 ships is required to be only 2,000 brake horse-power, in these vessels the speed is reduced to 233 r.p.m., giving the low mean effective pressure of, say, 56 lb. per square inch and a piston speed of 1,068 ft. per minute. In the ships with four engines driving a single propeller, the total machinery weight, including the reduction gearing and electric slip couplings, is 470 tons, or about 125 lb. per shaft horse-power. The engines alone weigh about 100 lb. per shaft horse-power.

The cylinder block is carried on cylinder supports mounted on the bedplate, and two steel tie rods extend from the bottom of each main bearing to the top of the block, which is of cast iron and in one piece. Each liner is divided into an upper and lower section, the upper section being provided with scavenging and exhaust ports. There are two rows of scavenging ports, extending round half the circumference of the liner and, while the lower ports are in direct communication with the scavenge trunk, the admission of the scavenging air to the upper series is controlled through automatic non-return valves. The piston is formed of a forged-steel top carrying the rings and cooled with lubricating oil, a relatively light cast-iron skirt, and a wrist-pin housing which is attached to the top of the piston within the skirt and transmits the pressure to the pin. Fresh water is employed for cooling the cylinder jackets and cylinder covers. The fuel-injection gear is of a special design developed by the manufacturers and the Aircraft and Diesel Equipment Company to deal satisfactorily with the heavy residual oil used in the engine. Individual camshaft-driven pumps are adopted, with duplicate cams for ahead and astern operation. Reversal is effected by moving the camshaft in a fore-and-aft direction to bring the requisite cams into action. The nozzle valves are water-cooled and are actuated in the ordinary manner by the pressure of the fuel oil. The lubricating oil for cooling and lubrication, and the

AMERICAN DIESEL ENGINES.

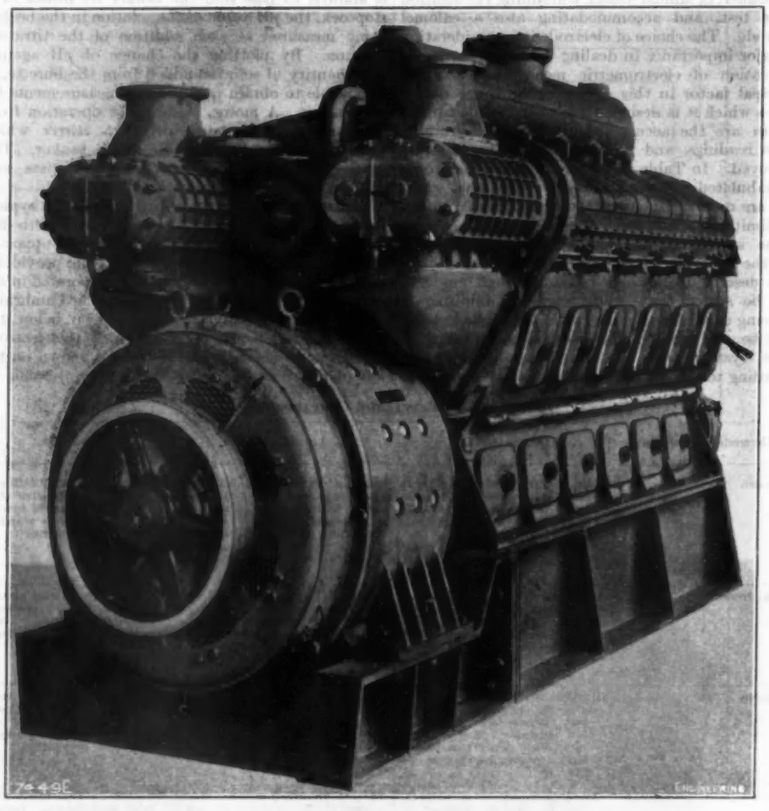


FIG. 4. 950-B.H.P. G.M. ENGINE AND GENERATOR.

6,000-B.H.P. SUN-DOXFORD MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. SUN SHIPBUILDING AND DRY DOCK COMPANY, CHESTER, PENNSYLVANIA, U.S.A.

(*For Description, see Page 23*).

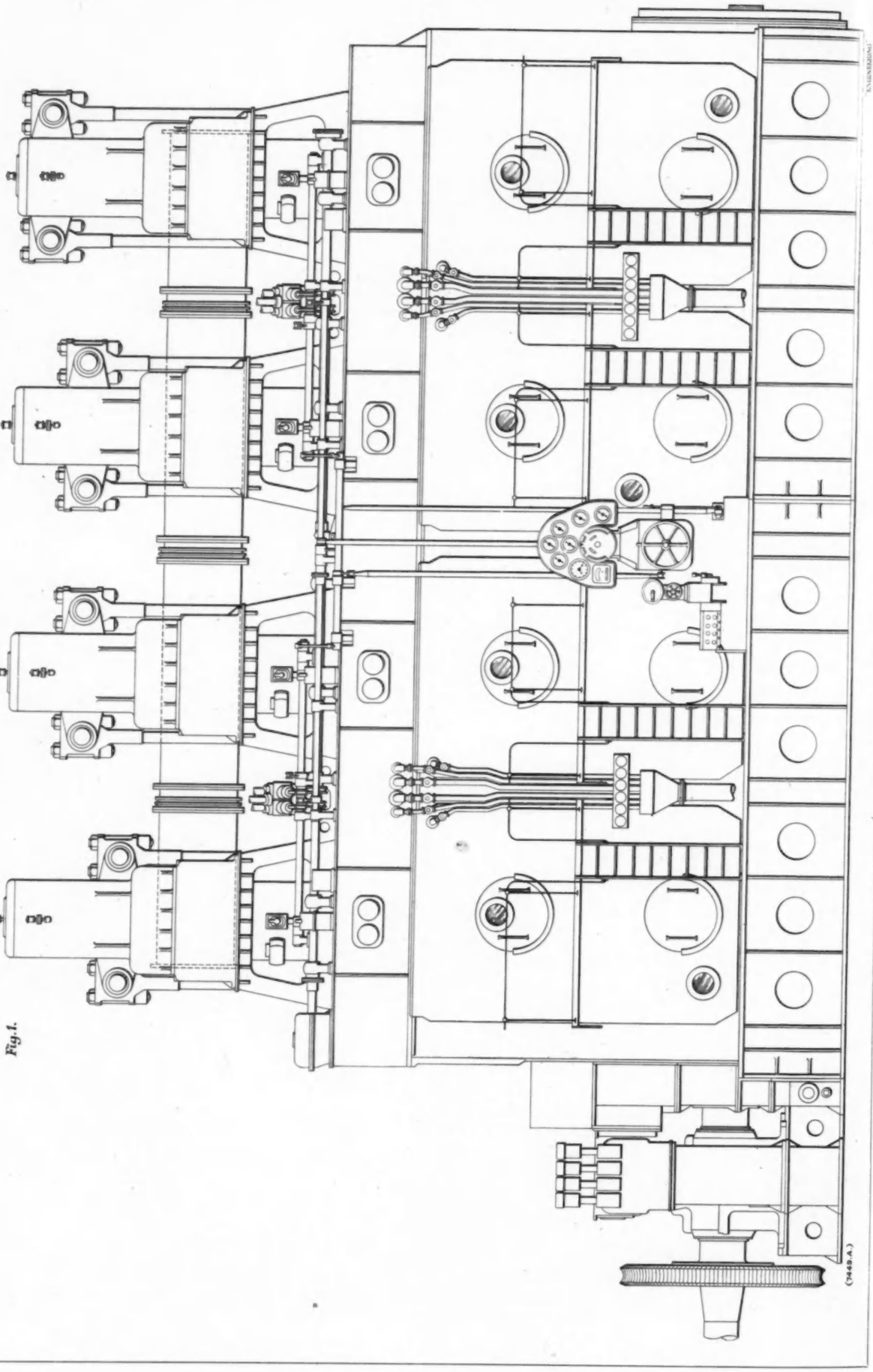


Fig. 1.

6,000-B.H.P. SUN-DOXFORD MARINE DIESEL ENGINE.

CONSTRUCTED BY MESSRS. SUN SHIPBUILDING AND DRY DOCK COMPANY, CHESTER, PENNSYLVANIA, U.S.A.

(For Description, see Page 23.)

Fig.2.

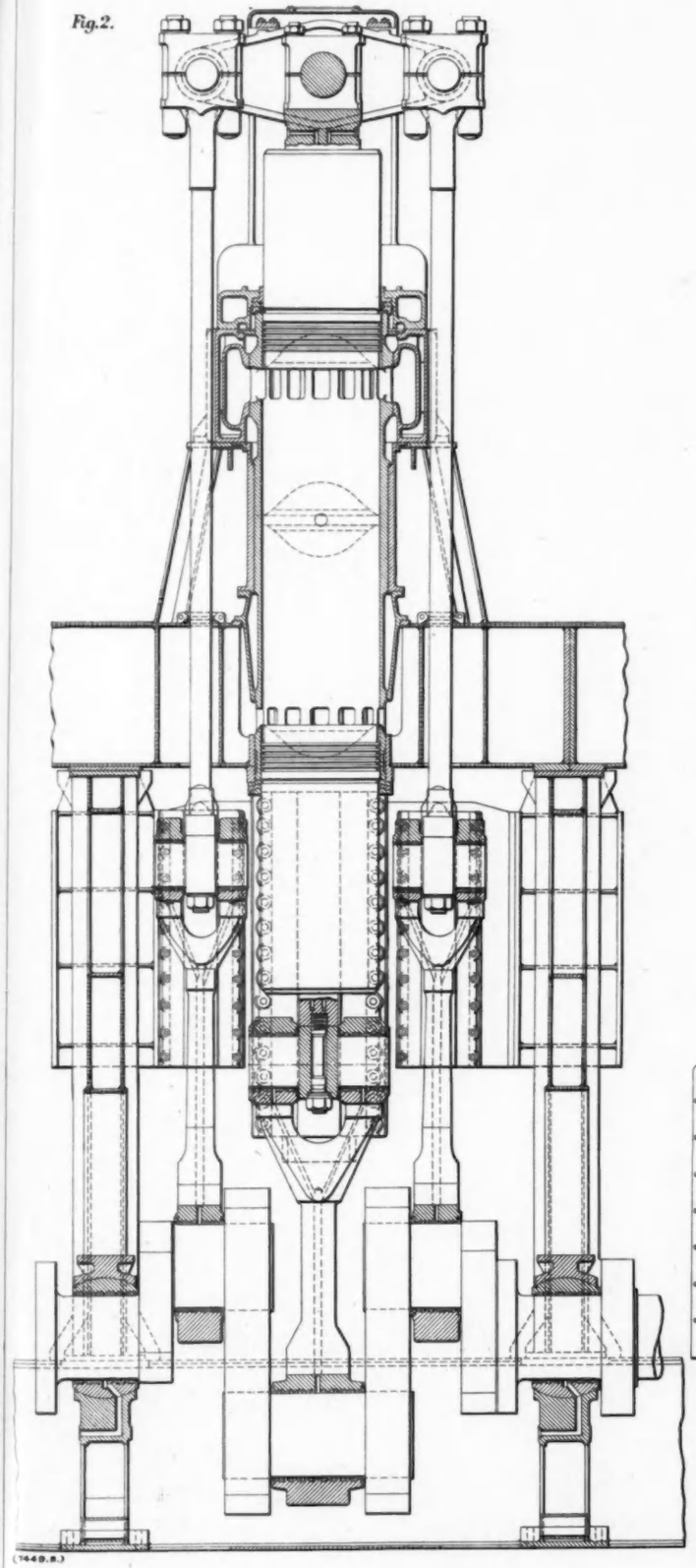
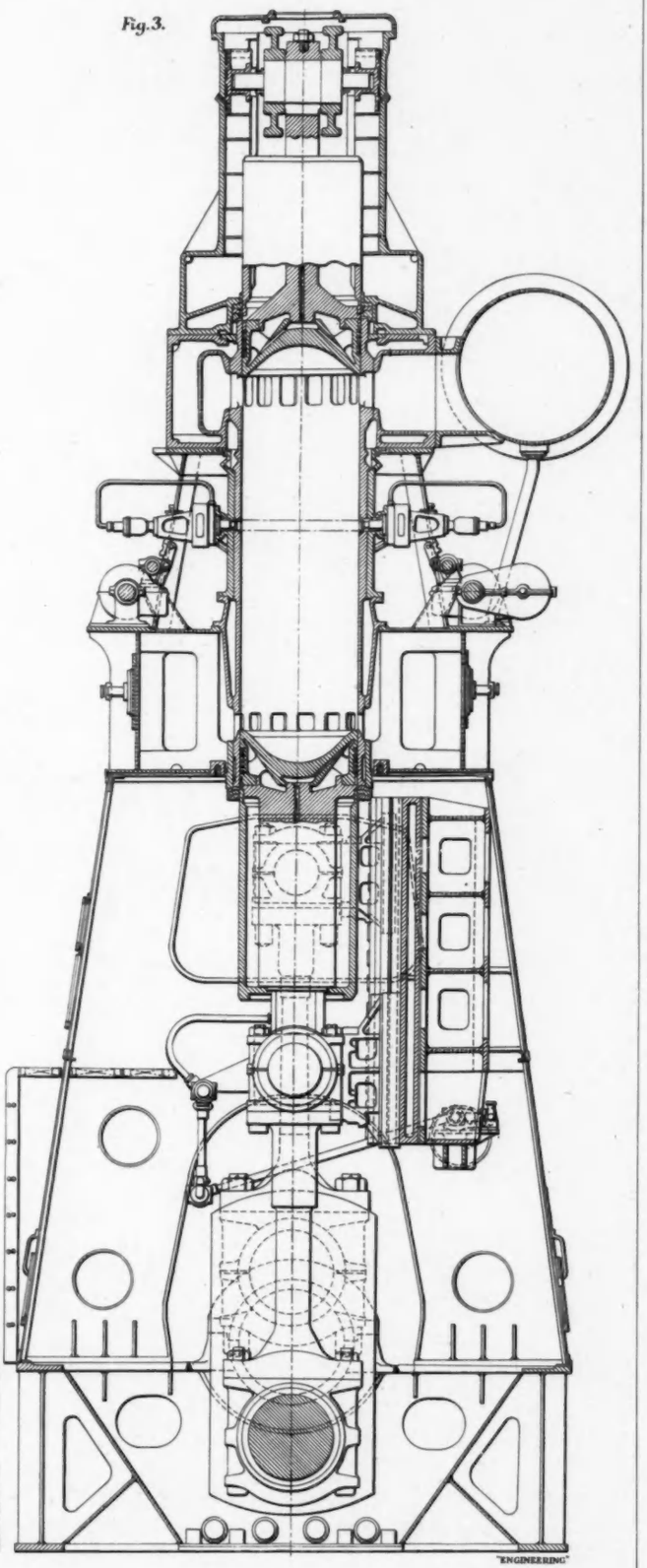


Fig.3.



UNIV. OF MICH.

fresh-water circulation, are supplied by separate electrically-driven pumps.

During the course of shop trials, using fuel with a specific gravity of 0·97, the fuel consumption at full load was found to be 0·37 lb. per shaft horse-power per hour. The maximum output was 2,600 brake horse-power at 252 r.p.m., and the corresponding mean effective pressure about 65 lb. per square inch. For a two-engined installation, the overall length with gearing and electric slip couplings is 37 ft., the corresponding length for a four-unit plant being 51 ft. and the height above the centre of the crankshaft 11 ft. 3 in.

In a considerable number of the United States Maritime Commission's C2-class cargo ships, the machinery installation comprises two Nordberg 3,000-brake horse-power engines, driving the propeller shaft through Vulcan hydraulic couplings and mechanical gearing. The Nordberg engine, although previously built in considerable numbers for stationary purposes, had not hitherto been adopted for large ship propulsion, and the design now used for this purpose is a modification of the type employed for driving generators on land, and for similar purposes. It operates on the two-stroke single-acting principle, but, unlike the Busch-Sulzer engine, is of the crosshead type, and has a single row of scavenge ports, the whole of the air being admitted to the cylinder through automatic valves located within the scavenge trunk. There are nine cylinders with a diameter of 21 in., the piston stroke being 29 in., and the output of 3,000 shaft horse-power is maintained at 225 r.p.m. as a normal rating, with a corresponding propeller speed of 92 r.p.m. The specification calls for a continuous overload capacity of 10 per cent. at 95 r.p.m. and of 25 per cent. for two hours (3,750 shaft horse-power) at 242·5 r.p.m. At normal output, the mean effective pressure is 59 lb. per square inch. The box-form bedplate carries the frames on which the cylinder block is mounted, and through bolts are fitted from the bottom of the bearings to the top of the cylinders. Scavenging air is supplied from a rotary displacement pump, driven by gearing from the after end of the crankshaft and discharging directly into the horizontal scavenging trunk, which extends for the whole length of the engine.

It may be recalled that, about three years ago, Burmeister and Wain developed a new system of reversing in which the camshaft is held stationary while the engine crankshaft continues to turn through a small angle, so that the fuel cams are then set for astern running. In effect, there is an angular displacement between the camshaft and the crankshaft. This is effected by means of a brake cylinder, and during the same operation the scavenging-blower reversing valve is also set in its required position for running astern. This method has been adopted in the Nordberg engine. An over-speed pendulum governor, also of Burmeister and Wain design, is employed, which is usually set to shut off the fuel when the engine speed rises 15 per cent. above the normal. For cooling the cylinder jackets and covers, fresh water is employed, with lubricating oil for piston cooling, the circulation being maintained by independent electrically-driven pumps. A special feature of the design in connection with the geared installation is that the piston-cooling and lubricating oil is also utilised for the Vulcan hydraulic couplings. For the supply of the lubricating oil to the main bearings, the crankshaft is drilled through the crankpins, webs and journals. There is a separate fuel pump for each cylinder; the pumps are not grouped together to form one unit, but are arranged on the centre line of each cylinder, with direct vertical fuel piping to the appropriate valves. The pumps are of Bosch design and the fuel injectors are water-cooled. In each cylinder head, in addition to the fuel-injection valve, there are the starting-air and relief valves. The admission of the air through these valves for starting purposes is controlled by air distributor valves arranged adjacent to the control position, which is at the after end of the engine. The two engines are normally manœuvred as one unit, although they may be disconnected if required.

The only remaining Diesel engines built in America for the propulsion of large or high-powered ships are the Hamilton and the G.M. types. The manufacturers of the former, Messrs. The Hooven, Owens Rentschler Company, build under licence from the M.A.N. Company, and all their engines are of this class, without any modifications of importance. Actually, very few marine units have been constructed, but some are now passing through the shops for installation in the Maritime Commission's C1 motor vessels.

The G.M. engine deserves special mention on account of the policy associated with its production. It is manufactured by the Diesel Engine Division of the General Motors Corporation, which acquired the Winton Engine Company some time ago, remodelled its products, and greatly enlarged its factory. It was decided to concentrate wholly on Diesel-electric propulsion; in particular, for vessels such as high-powered tugs and dredgers requiring machinery up to 3,000 brake horse-power. Complete Diesel-engined generating units were standardised, of a class which could be utilised either for marine work or for Diesel-electric locomotives. The combined demand for such plant is sufficient to enable production to be carried out on a relatively large scale of entirely standardised units with the same cylinder dimensions. The engine most commonly constructed, and fitted in the majority of recently-built high-powered tugs and similar craft, is a 12-cylinder unit with a cylinder diameter of 8½ in. and a piston stroke of 10 in., the output being 950 brake horse-power at 750 r.p.m. A typical unit, coupled to a generator, is shown in Fig. 4, opposite. One, two or four of these plants are installed in the various types of craft that have been built hitherto, the current being supplied to a single motor of the high-speed type, geared down to give an efficient propeller speed. The combination thus represents a new idea in propulsion on a standardised basis, and, with the enormous resources of the General Motors Corporation, it is believed that such installations will ultimately be largely adopted in normal cargo ships.

The standard engine is of particularly interesting design, being of the Vee two-stroke type, with four mechanically-actuated exhaust valves in each cylinder head. Scavenging air is supplied through ports from two rotary displacement blowers. Steel plate, electrically welded, is employed in the framework. The piston is of Perlitic iron, electrically plated with a protective coating of tin, and is oil cooled. Both the camshaft and the scavenging blowers are driven from the gear train at the flywheel end of the engine. The pump supplying the oil for cooling the pistons is independent of the lubricating-oil circuit, in which are two pumps, one to deliver the oil to the main pipe system and the other to discharge it through filters and coolers from the sump to the tank. A novel type of fuel gear is employed, the oil pump and injector valve being combined to form a single unit, the only moving parts of which are the plunger and the needle valve.

While there are no other American engines built for installation in large vessels, the number constructed for the propulsion of smaller craft is exceptionally great. In fact, in this branch of Diesel engine development, the United States is probably on an equality with any other country, and there are at least 30 or 40 well-known designs, manufactured in sizes up to 500 brake horse-power, for propulsion of fishing vessels, coasters, small tugs, local passenger boats and similar craft. Practically without exception, all vessels of these classes are equipped with internal-combustion engines. Steam machinery for their propulsion is now almost unknown.

As stated earlier in this article, most of the ocean-going motor ships building in America are arranged for indirect propulsion, the drive being taken either through Vulcan hydraulic couplings or Westinghouse electric slip couplings. The former are of the normal direct-drive type, comprising the impeller and the driven wheel. Filling with the lubricating oil takes place through the pinion shaft from a gravity tank, providing a pressure of about 10 lb. per square inch. The filling and pumping are regulated by valves actuated by a motor, these being arranged on the main control panel. The coupling efficiency is 97 per cent.

The electric couplings are stated to have an efficiency of 97·5 per cent. For this purpose the Westinghouse Company have developed a new design (in Europe, the A.S.E.A. slip coupling has been used to a considerable extent). It has two rotary members with an air gap between, one being carried on the engine shaft and the other coupled to the gearing. The former receives current from the ship's auxiliary generators, and the inner rotor, with a squirrel-cage winding, rotates within the field of the external member. The rotation of the external member gives rise to a rotating magnetic field with a consequent induction of current in the squirrel-cage winding. The forces created by the resulting magnetic interaction cause the squirrel-cage rotor to follow at a slightly reduced speed, due to the slip. With this design, any of the engines, even in a four-engined installation driving a single shaft, may be disconnected from the others; while manœuvring is simplified, since, if necessary, two engines may be run ahead and two astern. The outer member has 24 laminated poles with copper strap field windings, and the current in the field may be reduced to 70 per cent. when the ship is operating at half speed. At least a dozen of the ships building are provided with electric slip couplings, including the vessels with geared Sun-Doxford engines.

It is the intention of the United States Maritime Commission to obtain the most detailed information and data relative to the performance in service of all of the ships built to their account. This includes the steamers and the motor vessels and, in view of the various types of machinery which are being installed, it is clear that a mass of data will be available in a few years' time which should prove of the greatest value to engineers, shipbuilders and shipowners. This work is entrusted to a special Research Department of the Commission, and, as ships with competitive types of propelling machinery will operate on similar routes and under similar conditions, the results of sea service should be more informative and conclusive than is usually possible.

NOTES ON NEW BOOKS.

Mechanical Engineering. By W. H. ATHERTON, M.Sc., M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 4*s.* net.]

THE title on the cover of this book would seem to be somewhat misleading, being rather reminiscent of such purely technical works as the well-known "Lineham." A better indication of the contents is given on the title-page, which reads *Mechanical Engineering, the Profession and its Opportunities.* The book is unusual in that, apart from its appeal to the engineering beginner, it contains much information which will be appreciated by the non-professional parent or guardian, who wants to know what mechanical engineering has to offer a son or ward. In the earlier chapters, an engineer's early training, sources of knowledge, scientific and technical education, and remuneration are dealt with. The advice given in these sections is practical and sound. Sections on technical reports and specifications and estimates follow. Then the second part of the book goes on to deal with materials and designing. The section on materials gives no more than a rapid survey of the commoner engineering materials; thus, while aluminium is dealt with, magnesium alloys are not. Among the ferrous materials, malleable cast iron is described in much more detail than any other metal. This section as a whole is uneven, and some of the materials might well have been discussed at greater length; for example, the concluding remark that manganese steel "cannot be machined by ordinary cutting tools," leaves the student without any indication of how it is machined. The chapters on some machine elements, principles of design, drawing-office practice, and so forth, are all of a general character, containing neither illustrations, examples nor formulæ. The suggestions intended to guide a young engineer's reading might have been considerably extended and modernised.

Determination of Scantlings for Masts, Derrick Posts, and their Fittings. By DAVID M. CARNEGIE. Epsom: The Draughtsman Publishing Company, Limited. [Price 2*s.* net.]

HISTORY has repeated itself rather curiously in the matter of the cargo-working appliances of ships. In the sailing vessels of half a century ago, it was customary for the crew to handle cargo in foreign ports, for the reasons that shore facilities were not always available

and cargo working by a shore crew was slower and less convenient in the case of a sailing ship than with the more simply rigged steamer. In recent years, the ship's gear has again assumed prominence with the demand for tackle capable of heavy lifts. In both instances, the designer of the masts and lifting tackle has problems to consider which are somewhat outside of the normal practice in the construction of hoisting appliances for shore use. Mr. Carnegie's pamphlet, which is one of the familiar series sponsored by the Association of Engineering and Shipbuilding Draughtsmen, is a compact summary of the essentials in designing masts and derrick posts of both riveted and welded construction, and contains also a number of typical detail drawings of heel fittings, topping fittings, etc., with much tabulated information about rigging screws, thimbles and splices, eyeplates, shackles, etc. Specimen calculations are given, which appear to cover most problems likely to be encountered in the ordinary run of shipyard work, and include the design of mast deck-bracket connections. The pamphlet may be commended as a straightforward study of a subject which is not always given sufficient attention in text-books on naval architecture; though, once again, we would suggest that more care might be bestowed on the illustrations, the quality of which is very uneven. In the official publications of the Draughtsmen's Association, the draughtsmanship, at least, should be above reproach. The make-up, too, might be improved; grouping the diagrams together at the end of the matter is not a convenient arrangement for reference, and the fact that certain illustrations in the text are not numbered is rather confusing at first.

Engineering Economics. Book I.—Elements of Industrial Organisation. By T. H. BURNHAM and G. O. HOSKINS. Fifth edition. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

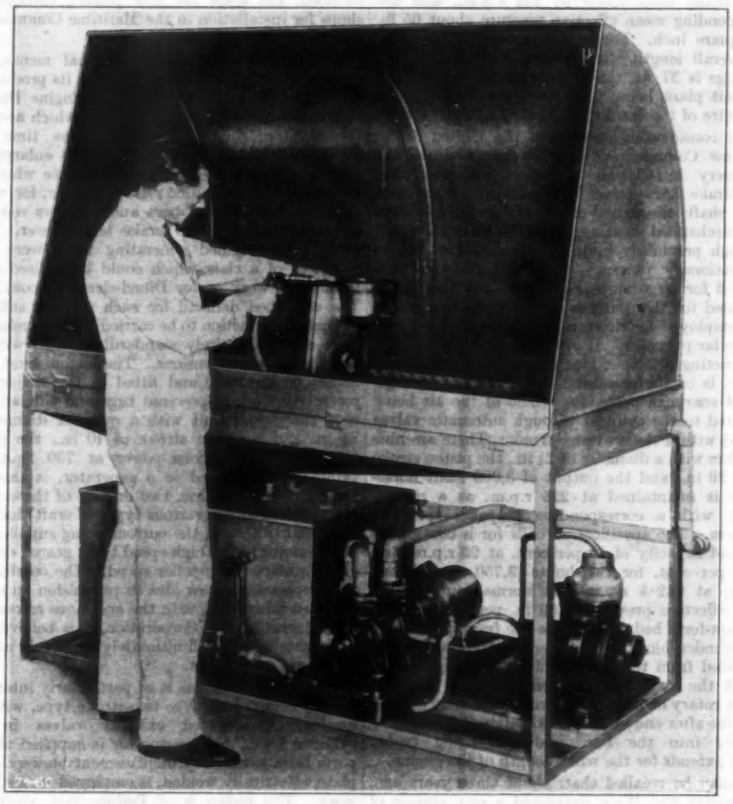
THIS book, originally written by Mr. Burnham alone and now considerably revised, has become so well known that no description of its general plan is necessary. The authors state that the chapters on the elements of economics and money, and banking and exchange, have been entirely rewritten; and those on resources and business organisation have been "reconstructed" with the addition of much new matter. A new chapter has been introduced, on "The Trade Cycle." The progressive revision of the rest of the sixteen chapters, which has continued steadily from edition to edition, now amounts to a cumulative improvement which is very marked in comparison with the early editions; and the book now provides a thoroughly useful preparation for Section C (Economics of Engineering) of the associate-membership examination of the Institution of Mechanical Engineers and the corresponding sections of the examinations of the Institution of Production Engineers and the Institution of Electrical Engineers. In a few respects, however, it still affords opportunities for further revision. Some criticism in detail might be levelled against the authors' suggestions for extended reading, under the different chapter headings—though, obviously, this is a matter which depends much on personal opinion; and, in connection with Chapter IV ("Industrial Evolution") they might do well to browse awhile in the *Transactions* of the Newcomen Society. Samuel Smiles is generally dependable, but he was not infallible; and research has brought many facts to light since his day. The bibliography to this chapter ought now to include H. T. Pledge's *Science Since* 1500 (H.M. Stationery Office). Incidentally, Henry Cort's works was at Fontley, Hampshire—not "Surrey-street, London," as stated; and the references to the Manchester Steam Users' Association (page 309) should now be in the past tense. Some of the views expressed on sociological topics will not find universal acceptance.

Lift Handbook. By L. J. GOOCH, A.M.I.E.E. London: Marryat and Scott, Limited. [Price 10*s.* 6*d.* net.]

THIS well printed and well illustrated little book deals with the important problem of lift maintenance from a refreshingly novel aspect. After a brief general description of an electric lift, the author proceeds to trace the historical developments of the controller in such a way that the main principles underlying lift control can be assimilated by anyone having only elementary electrical knowledge. The second half of the book is devoted to maintenance and is written in such a way that, if the instructions given are followed, anyone, even those not versed in lift practice, should be able to give ordinary attention to a lift without harming themselves or the machine. A useful section is devoted to the tracing of troubles. This contains a number of charts, by the use of which it should be possible to trace the more common faults causing lift stoppages by a process of elimination, and when found, to rectify them. The information given is clear and detailed, and most of the "incidents" that are likely to arise seem to be covered.

PARAFFIN WASHING EQUIPMENT.

MESSRS. ALFA-LAVAL COMPANY, LIMITED, BRENTFORD.



PARAFFIN WASHING EQUIPMENT.

THE utility of paraffin for cleaning machine parts prior to re-conditioning is generally recognised and the operation is commonly practised in the workshop, it being also the custom in some instances to clean in this manner finished parts from the machines destined for the stores. Messrs. Alfa-Laval Company, Limited, Great West-road, Brentford, Middlesex, have recently developed a compact equipment, known as the "Parawash Unit," which displaces the usually improvised arrangements, and, what is more important, enables the dirt and swarf to be removed from the washing paraffin, which can be used again as often as required. The equipment is illustrated by the photograph reproduced on this page, from which its layout can be understood at a glance. The operating bench consists of a hooded table with a surface of perforated metal above an unsymmetrical hopper. The bench, hood and hopper are of welded steel and the base of the former is arranged with cross-members to carry the components of the paraffin-circulating and separating plant.

This plant consists of a tank divided into two compartments, a motor-driven pump supplying paraffin under pressure to the cleaning nozzle and a motor-driven centrifuge which separates the dirt from the used paraffin. These three elements can be seen in the illustration arranged from left to right. The cleaning nozzle consists of a pistol-type spray gun with a trigger-operated valve. The contaminated paraffin, after passing through the perforated plate which arrests large pieces, such as lumps of oil-caked mud from a vehicle gearbox, then passes through a finer strainer situated below the hopper into the left-hand compartment of the tank. In this compartment some degree of settlement takes place, and the paraffin, thus partially-clarified, flows over a weir in the dividing partition into the right-hand tank. A connection from this tank is made to the inlet side of the pump of the De Laval centrifugal clarifier, which is belt-driven by a ¼-h.p. motor. The discharge from the clarifier is returned to the right-hand tank, the paraffin in which is thus continuously kept clean. This tank, it will be seen, is provided with a gauge glass to enable a correct level to be maintained and the clean paraffin prevented from flowing back over the weir into the dirty-oil compartment. The contents of the latter compartment may be passed at will through the clarifier, a three-way cock, seen below the gauge glass, being provided for this purpose.

The clean paraffin is drawn from the right-hand tank by a centrifugal pump directly-driven by a ¼-h.p. motor, and is delivered at high pressure to the spray-gun through the pipe seen running across the back of the base and up to the table, at which point a flexible connection is fitted. The branch of the delivery pipe leading back to the tank is fitted with a relief valve to avoid excess pressure when the spray is shut off and the pump is running. The relief valve discharge is led, of course, to the right-hand compartment of the tank. The continuous cleaning of the spraying medium adds greatly to the efficiency of the operation of paraffin washing. The Parawash unit is entirely self-contained, and is neither too bulky nor too heavy to prevent transport from site to site, the only connections required being the electric cables to the motors.

MALAYAN RUBBER INDUSTRY.—A statement issued by the Registrar-General of Statistics for the Straits Settlements and the Federated Malay States, shows that the ocean shipments of rubber, including latex, concentrated latex, and revertex, at all Malayan ports during the first ten months of 1940 was 651,080 tons. The total for the corresponding period of 1939 was 462,480 tons.

CONTROL OF EXPORTS TO EIRE.—The Board of Trade has issued a new Order, known as the Export of Goods (Control) (No. 43) Order, 1940, which came into force on January 1, 1941. Under the terms of this Order, the export to Eire of dies of diamond and metallic carbide, and tools and tool parts of which the cutting edge is tipped with diamond or metallic carbide, is prohibited, except under licence from the Board.

18-IN. CENTRE MOTOR-DRIVEN BREAK LATHE.

MESSRS. TANGYES LIMITED, BIRMINGHAM.

Fig. 1.

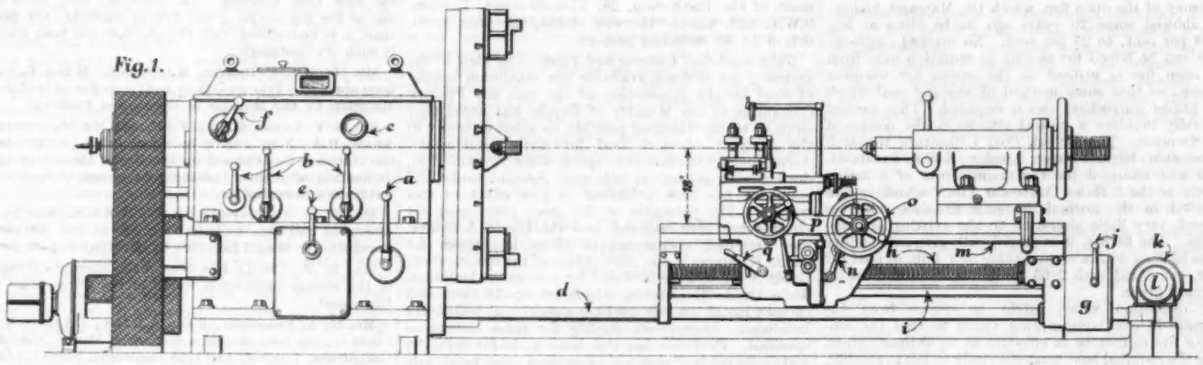


Fig. 2.

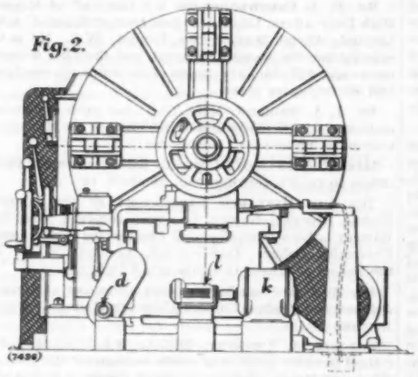
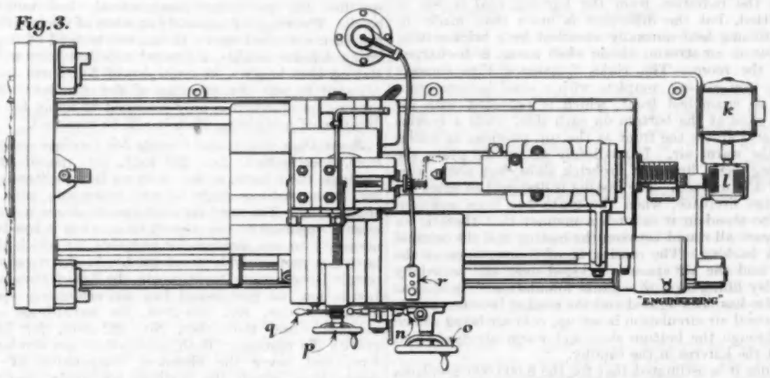


Fig. 3.



18-IN. CENTRE MOTOR-DRIVEN BREAK LATHE.

THE 18-in. centre break lathe illustrated in Figs. 1 to 3, on this page, may, at first appear somewhat out of proportion, since the headstock and faceplate look unduly heavy and the saddle traverse towards the headstock is apparently limited. A more careful examination of the figures will show, however, that the saddle, although having independent traverse on the bed, can be moved as close to the faceplate as is normally required since the bed itself can be traversed on the baseplate on which the headstock is mounted. The massiveness of the headstock and faceplate is accounted for by the fact that the lathe is designed to permit very heavy cuts to be made on greatly overhung work carried directly on the faceplate, the material of the work being 65 ton tensile steel. The lathe is one of a number recently completed by Messrs. Tangyes, Limited, Cornwall Works, Birmingham. It has sliding, surfacing and screw-cutting motions and, as regards these, is driven by a constant-speed motor of 25 h.p. running at 940 r.p.m. The bed is traversed by an independent constant-speed reversible motor of 5 h.p., running at 1,430 r.p.m. The power and constructional margins provided, we understand, are well in excess of the particular requirements called for in order to meet possible heavier demands without risk of breakdown and loss of accuracy, and to meet the conditions imposed by modern tipped tools and double working shifts.

Dealing first with the headstock and referring particularly to Figs. 1 and 2, it will be noticed that the faceplate is of the four-jaw type. It is 5 ft. 6 in. in diameter and the jaws are of hardened steel of the reversible, hand-adjusted type. The faceplate, in addition to the 8 slots for the jaws, has 8 radial Tee-slots for bolting work directly to it. The spindle is of high-carbon steel running in bronze bearings. It is driven from the motor by means of multiple Vee-belts and gearing, the motor being arranged on an adjustable slide to provide correct belt-tensioning. All the shafts are of high-quality steel and run in ball bearings. The gears are of nickel steel hardened and ground and, where movable, slide on splined shafts. Starting and stopping control is by means of the lever *a*, which actuates a friction clutch fitted with a brake. The three levers indicated at *b* provide 16 changes of spindle speed, the range being divided into a closely-stepped group of from 1 r.p.m. to 1·75 r.p.m., a more widely-stepped one of from 2 r.p.m. to 9 r.p.m., and one with still larger intervals of from 12 r.p.m. to 60 r.p.m. The spindle speed actually in use is shown on a tachometer at *c*. The lower part of the headstock contains a four-speed gearbox from which all the feed motions are derived, the gearbox drive being transmitted to the saddle by means of the shaft *d* running the full length of the machine baseplate.

The gearbox is driven by change wheels from the spindle drive, an arrangement which enables a very large number of feed changes to be obtained, since the gearbox itself has four changes. The gears are proportioned in ratios of 1 to 1, 2 to 1, 3 to 1, and 4 to 1. With equal change wheels these ratios give turning feeds of 0·2 in., 0·1 in., 0·066 in., and 0·05 in. per spindle revolution; surfacing feeds of 0·166 in., 0·083 in., 0·055 in., and 0·041 in. per spindle revolution, and screw-cutting feeds of 2 threads, 4 threads, 6 threads and 8 threads per inch. Other rates obtainable depend, of course, on the ratios of the change wheels employed in the gearbox drive. The four changes referred to above are obtained by sliding gears actuated by the gate-controlled lever *e*. The feeds are reversed by the lever *f*. All the feed motions are interlocked on the saddle so that no two can be in operation simultaneously. Mechanical lubrication is provided for all the gears, shafts and spindle bearings in the headstock, the operation of the lubrication being visible through a window in the cover.

The construction of the sliding bed will be clear from the right-hand portion of Fig. 1, from the end view, Fig. 2, and the part plan, Fig. 3. The baseplate is cast with a trough all round for receiving the cutting lubricant and the bed slides on it on two ways, one of which is partly visible in Fig. 2. The shaft *d* is supported in a bearing at the end of the baseplate and passes through a box *g* on the bed in which are situated the gears by which its motion is transmitted either to the lead screw *h* or the feed shaft *i*, selection of either motion being effected by the lever *j*. The bed-traversing motor is mounted on a bracket at the end of the baseplate and is indicated at *k*. The motor drive is transmitted to the bed through worm reduction gear at *l*, Fig. 2, the final drive being by means of a rotating screw with a fixed nut in the bed. The upper face of the bed has three ways, which carry between them both the saddle and the tailstock, as shown in Fig. 2. The tailstock is adjustable along the bed, and is traversed by a hand-actuated pinion meshing with the rack *m*. The tailstock spindle is traversed by screw and nut, the latter being attached to a large-diameter handwheel. A locking lever is provided.

The saddle has, in addition to a cross-slide of exceptional length, a separate incutting slide, *i.e.*, a slide moving parallel to the saddle traverse. This slide is fitted with a rapid withdrawal movement. For the ordinary feed motions the slide is coupled to the shaft *i* by manipulation of the lever *n*. The handwheel *o* is for hand traverse of the saddle by means of the rack *m*. The wheel *p* is for hand traverse of the cross-slide. Micrometer dials are provided for the slide traverses. The saddle is coupled to the lead screw *h*, by means of the lever *q*, which actuates a split nut. A dial indicator shows the rate of saddle traverse when screw-cutting. A push-button control *r* on the saddle enables the operator to start and stop the main spindle from the cutting position. The saddle bearings, etc., are grease-gun lubricated. The cutting lubricant pipe is carried on the saddle, a flexible supply pipe from the suds pump permitting the relative movement between the saddle and the bed. The lathe has an overall length, including the motors, of approximately 24 ft., and a net weight, also including motors, of 17½ tons.

AMERICAN OIL PRODUCTION.—The daily output of crude oil in the United States, in the week ending December 21, averaged 3,621,200 barrels, an increase of 42,250 over the figure for the previous week.

THE ABLETT PRIZE.—As stated in our columns at the time, it was announced in the course of the Autumn Meeting of the Iron and Steel Institute, held in Sheffield in November, that the Council had accepted the offer of Captain C. A. Ablett, O.B.E., B.Sc., M.Inst.C.E., to renew his prize of 50*l.* for a paper on a subject connected with engineering in iron or steel works, for competition in 1941. We now learn that competing papers, which should be marked "Ablett Prize Paper," should reach the Secretary of the Institute not later than May 31, 1941. The only condition laid down respecting authors of papers is that they shall be British subjects employed in the iron and steel industries of Great Britain or the British Empire. Both members and non-members of the Institute may compete. The successful paper will be presented at the Autumn Meeting in 1941, and will subsequently be printed in the *Journal* of the Institute.

ECONOMY IN DOMESTIC COAL CONSUMPTION.

THE difficulties attendant upon the supply of domestic coal at the present time serve to emphasise the necessity for reducing its consumption by increasing the efficiency of the open fire, which Dr. Margaret Fishenden showed some 20 years ago to be often as low as 18 per cent. to 25 per cent. No marked improvement can be hoped for as long as radiation only from the open fire is utilised as the means for warming a room, so that some method of burning coal which will utilise convection also is required. This method naturally involves a radical change in the design of the fireplace. The British Coal Utilisation Research Association, Rickett-street, London, S.W.6, has developed and arranged for the manufacture of a fitting known as the "Hales Convector Fire," which can be installed in the normal domestic fireplace with, in general, very little alteration to the existing arrangements. The fitting, it is stated, will give satisfactory room-heating with a consumption of 1·6 lb. of coal per hour, compared with 2·65 lb. per hour needed for an ordinary grate.

A deduction which might be drawn from the decrease in coal consumption would be that the convector fire cannot be so effective as an ordinary grate, since the radiated heat must obviously be less in amount. That the radiation from the burning coal is less is admitted, but the difference is more than made up by utilising heat normally absorbed by a brick-setting to heat an air stream, which, when warm, is discharged into the room. The Hales Convector Fire consists of an iron casting complete with a stool bottom grate and an enamelled front, which is provided with air inlet slots at the bottom on each side, while a louvre-like grid across the front at the top provides an outlet for the warm air. Immediately above the grate the casting has a lining of firebrick slabs, but above this level it is unlined. The casting is designed to enter the average fireplace, when the grate has been removed and to stand in it in such a manner that there is an air space all round between the casting and the original brick backing. The casting is, of course, open at the top, and the air space is bridged over and sealed by fireclay filling on a wire gauze foundation. As soon as the fire has been lighted and the casting becomes warm, a natural air circulation is set up, cold air being drawn in through the bottom slots and warm air discharged from the louvres in the canopy.

Since it is estimated that for the 8,000,000 fireplaces in regular use in the winter in this country there are some 2,000 different designs of grate varying in age, size and type, it was obviously impossible to find a single pattern of casting which could be used in all cases. In its present form the Hales Convector Fire is suitable for use in most 16-in. fireplaces of modern design, and may often be fitted without difficulty into an 18-in. grate, and this would also apply to a number of the earlier types. As regards availability, it is stated that the Ministry of Supply, realising the importance of reducing domestic coal consumption, has allocated sufficient cast iron to enable 10,000 convectors to be manufactured. Apart from the fact that tests have shown the Convector Fire has a total heat output more than 40 per cent. greater than that from the ordinary open fire for the same fuel consumption, two other aspects may be commented upon. The decrease in coal consumption for heating and cooking, which amounts to some 35,000,000 tons to 40,000,000 tons annually, should conduce to the cleanliness of the atmosphere, which is a matter of considerable importance. Secondly, due to the design of the outlet throat of the convector, which design is based on previous research into the aerodynamics of open fires, a marked decrease was noticeable in the air-flow through the room in which the new appliance was tested. In consequence, there should be a reduction of draughts in a room fitted with the convector fire, though it is anticipated that this will not interfere with adequate ventilation. We understand that the Hales Convector Fire may be examined at the Building Centre, the address of which is 158, New Bond-street, London, W.1.

THE LATE CAPTAIN ALEXANDER WILLIAMSON.—The death is reported, at Tighabruaigh, of Captain Alexander Williamson, O.B.E., formerly marine superintendent of the Clyde steamboat services of the Glasgow and South-Western Railway, and, from 1910 to 1918, a local director of Messrs. John Brown and Company, Limited, Clydebank. Captain Williamson, who was educated at Rothesay Academy and at Glasgow Academy, entered his father's Clyde steamer business at an early age, and secured his master's certificate at the age of 21. In recognition of his services during the last war, he was awarded the O.B.E. in 1918, in which year he retired. At his death, which took place on January 3, he was 84 years of age.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Galvanised-Steel Cisterns and Tanks.—In view of the necessity for making available the maximum supply of steel for the prosecution of the war, the Priority Committee of the Ministry of Supply has urged that steps be taken, wherever possible, to affect economy in the quantity of steel used for civil requirements. Accordingly, war-emergency specification No. 417-1940, dealing with galvanised mild-steel cisterns, tanks and cylinders, has been published to give effect to this request. The thickness of the steel plate used for cisterns has been reduced, and the Grade A figures, now specified, correspond to those laid down for Grade B cisterns in the 1936 edition of the specification. Grade A cisterns are intended for permanent buildings, while Grade B cisterns, which are made from still thinner metal, are for semi-permanent and temporary buildings. Appropriate staying for these cisterns is specified. Provision has also been made for cylinders and tanks made of sheets thinner than those previously specified for use under comparatively low working heads. The range of nominal diameters of the cylinders has been extended up to 42 in., but instead of stipulating definite heights, a general note has been added stating that heights, in multiples of 3 in., are to be adjusted to suit the capacity of the cylinder. The present specification is only intended to apply for the duration of hostilities, when it will be reviewed.

Brass Die Castings and Gravity Die Castings.—Apart from specification No. 208-1924, for special brass castings, there have, so far, been no British Standards for brass castings such as are commonly used in engineering. The need for such specifications is particularly apparent at the present time, when it has been necessary to use castings for purposes for which they have not previously been adopted. At the request of certain Government Departments, the British Standards Institution has just issued two war-emergency specifications: one, No. 920-1940, for naval-brass die-castings; and the other, No. 932-1940, for brass gravity die castings. Both publications are similar in form and cover the chemical composition of the ingots from which the castings are made, and the mechanical properties obtainable from the castings. For the naval-brass die castings an ultimate tensile-stress value of not less than 20 tons per square inch, with an elongation, on 2 in., of not less than 20 per cent., is specified. For the brass gravity die castings, a minimum tensile strength and elongation, on 2 in., of 18 tons per square inch, and 25 per cent., respectively, are specified. The two specifications, which should prove of distinct value to manufacturers, have been issued as war-emergency standards, so as to make them available to industry as quickly as possible.

COPPER DEPOSITS IN GERMANY.—It is stated in a recent issue of *The Metal Industry* that intensive exploration work conducted since 1935 has revealed the existence of extensive copper deposits in Permian limestone in the region of Bunzlau, Goldbert, and Löwenberg, in Lower Silesia, Western Germany. Recently-developed geological data indicate that these deposits are more extensive than had previously been supposed, and that they contain at least one million metric tons of metallic copper. Modern mining, milling and smelting methods make it possible to exploit the deposits on a commercial scale.

THE LATE MR. J. B. ALLAN.—It is with regret that we record the death of Mr. James Boyd Allan, which occurred at Prestwick, Ayrshire, on January 2. Mr. Allan, who was 83 years of age, was a former vice-chairman and managing director of Messrs. David Colville and Sons, Limited, and a director of Messrs. Archibald Russell, Limited, colliery owners, Glasgow. He entered the employ of Messrs. Colville upwards of 50 years ago as superintendent of the testing department at the Dalzell iron and steel works, Motherwell, and, on the death of Mr. John Colville, M.P., in 1901, he was appointed secretary to the company. Subsequently, he was made a director, and, in 1916, became managing director and vice-chairman of the company. Mr. Allan retired in 1931 when the amalgamation took place between Messrs. David Colville and Sons and Messrs. James Dunlop and Company, Limited, to form the firm of Messrs. Colvilles, Limited. In addition to his business activities, he took a great interest in education and served successively as chairman of the old Dalzell School Board, and as member of the Education Committees of the Lanark and the Ayrshire County Councils. He was also a member of the Prestwick Town Council.

PERSONAL.

HIS MAJESTY THE KING, on January 6, gave the accolade to MR. ALLAN JOHN GRANT, managing director of Messrs. Thos. Firth and John Brown, Limited, the announcement of whose knighthood appeared among the New Year Honours. The ceremony took place in one of the workshops of the firm at Sheffield—the first time, it is understood, that the accolade has been given in such circumstances.

MR. HUGH E. C. BEAVER, M.I.Chem.E., M.Inst.T., has been appointed Priority Officer and Controller of Building Materials by the Minister of Works and Buildings.

MR. E. V. EVANS, O.B.E., F.I.C., and MR. W. GORDON ADAM, B.A., F.I.C., have been appointed to represent the National Gas Council on the Grand Council of the Federation of British Industries in regard to chemical fertilisers and explosives.

MR. G. J. GREENFIELD, B.Sc., A.R.C.S., has been appointed full-time technical adviser to the Advisory Committee on Benzol Recovery by the Mines Department.

MR. R. W. COVILL has been made chemist-manager of the sewage-purification works of the Corporation of Gravesend.

MR. G. A. FRAMPTON, B.Sc., A.R.C.S., D.I.C., A.M.I. Chem.E., has been elected a director of Messrs. Sharples Centrifuges, Limited, Lightpill Ironworks, Stroud, Glos.

MR. P. A. CARTWRIGHT has left the staff of Messrs. High Duty Alloys, Limited, to join that of Messrs. C.A.V. Limited, Warple Way, Acton, London, W.3. He is to superintend the metals-treatment and finishing departments and will also have charge of the ammonia-cracking and electroplating plants.

MR. J. A. STORROW, M.Sc.,Tech., has been appointed assistant lecturer in chemical engineering at the Municipal College of Technology, Manchester.

MESSRS. NITRALLOY, LIMITED, have transferred their offices to 25, Taptonville-road, Sheffield, 10.

THE LAC RESEARCH LABORATORY of the London Shellac Research Bureau, has been removed from the Ramsay Laboratories, Chemical Engineering Department, University College, Gower-street, London, W.C.1, to the School of Mines, Grassmarket, Edinburgh.

MR. W. GLASS has been elected a director of Messrs. Johnson and Phillips, Limited, Columbia House, Aldwych, London, W.C.2.

COLONEL J. TENNANT, D.S.O., D.L., M.I.Mech.E., retired from his position of works manager of the Prescot Works of Messrs. British Insulated Cables, Limited, on December 31, 1940. He is, however, being retained as consultant, on plant matters, to the company and its subsidiaries. MR. D. W. ALDRIDGE, hitherto assistant works manager, has been appointed works manager as from January 1, 1941.

MR. HORACE BOOT, M.Inst.C.E., M.I.Mech.E., of Messrs. Horace Boot and Partners, 7, Victoria-street, London, S.W.1, who is a liveryman and past Master of the Worshipful Company of Cutlers, has been elected a Sheriff of the City of London, in place of Mr. G. Percy Trentham, who was killed in a recent air raid.

ENGINEER REAR-ADMIRAL R. C. HUGILL, who has been engaged for the past two years as technical director of the new Portuguese naval arsenal at Alfeite, near Lisbon, has now returned to London. His address is 30, Dartmouth-row, Greenwich, S.E.10.

TENDERS.

WE have received from the Department of Overseas Trade, Millbank, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained at the above address, quoting the reference numbers given.

Power Cable, single-core, tinned-copper conductor, vulcanised-rubber insulated, taped, braided and compounded, for voltages of not more than 250. Post and Telegraph Department, Wellington, N.Z.; February 6. (T. 23,550/40.)

Transformers, 73, outdoor-type, oil-immersed, self-cooled, of various ratings from 50 to 2,000 kVA. City Council of Pretoria, City Hall, Pretoria; February 3. (T. 23,639/40.)

ELECTRODES APPROVED BY THE BRITISH CORPORATION REGISTER OF SHIPPING.—A new list of approved electrodes for electric-arc welding has recently been issued by the British Corporation Register of Shipping and Aircraft, 14, Blythswood-square, Glasgow. The data given comprise the names of the makers and of the electrodes and the colours of the coatings and other distinguishing marks of the electrodes. Limitations in the use of some of the electrodes are also indicated. Copies of the list are obtainable on application to the Corporation.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The Ministry of Transport has announced that passenger traffic on the railways may be disorganised in certain parts in order to facilitate the movement of coal and freight traffic generally. The plan to aid collieries in the export areas which had been forced to close down owing to the loss of their export business was brought into operation during the week. This was a levy on all coal produced in the country to provide a fund for maintaining such collieries in a state of readiness to resume production when the demand occurred. Prices of South Wales coals have been advanced by 8*d.* per ton. This was the third increase since May last. The present increase, it was explained, was to provide for the levy scheme. The demand on the steam coal market from overseas buyers was still small, although a moderate interest was still being displayed on the part of Portugal and South America, to which countries deliveries were maintained at recent levels. The chief interest again centred in the high-volatile bituminous section, in which inland buyers were showing a keen interest. Stems for these coals were still difficult to arrange owing to the well filled order books of the producers. Dry steam coals obtained little support, and remained dull. Best large descriptions were still active and the sized sorts were eagerly sought after. Bituminous smalls remained scarce, but dry smalls were plentiful and dull. Cokes continued to attract a brisk demand from home users.

The Iron and Steel Trade.—Business in the iron and steel and allied trades was well maintained. The demand showed no sign of diminishing, and producers were engaged almost to full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Improved conditions are reported in all branches of the staple trades. Steelmakers are accounting for larger outputs, production having shown a steady increase over the past few months owing to the fact that extension schemes at many works have now been brought into operation. The heavy machinery and engineering branches are operating at full capacity, and some valuable orders have been executed during the past few weeks. Makers of railway rolling stock are busier. Among the products in demand are wheels, axles, springs, tyres, and buffers. There is a moderate overseas call, among the best customers being South Africa, Egypt, and India. Sales to South American countries are reported to be increasing. Dredging plant and dredger parts are in stronger request, and the call for plant used in the production of various types of precious metals has been maintained. New Zealand, India, Canada, and South Africa are the chief markets. Makers of special steels are finding some difficulty in meeting all requirements. Stainless steel in the form of bars and sheets is being absorbed in large quantities by several important industries, notably those producing dairy equipment, agricultural plant, textile machinery and chemical plant. There is also a heavy call for acid- and heat-resisting materials. Electrical equipment continues to be a progressive line; electric traction motors are on order from several overseas countries. The tool trades are operating at full capacity, and increased outputs are reported by several firms.

South Yorkshire Coal Trade.—The demand for most classes of fuel has improved during the past week. There is an active market in industrial coal, and steam coal is also in strong request. Foundry and furnace coke are active.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The Scottish steel trade in the new year is as fully occupied as it has ever been, and despite the fact that a record output was obtained during 1940 every effort will be made to equal, if not to exceed, the tonnage this year. At the present moment, the steelmakers have as much work booked as they can handle for the first quarter of the year and all consumers are anxious for early deliveries. To-day's prices are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade satisfactory conditions prevail at present, and the outlook for the immediate future is reassuring. The re-rollers of steel bars are extremely busy and record outputs have been general. The amount of work now on order involves the running of plant at full capacity for months ahead and, as fairly good supplies of semies have been arriving recently, the continuity of production is assured. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change has to be reported in the state of the Scottish pig-iron trade this week and production is being maintained at the high standard which has prevailed during the past year. The supply of raw material is ample for all requirements. The present quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The large aggregate output of iron and steel, supplemented by substantial supplies of American products, is providing sufficient tonnage for the exceptional requirements of work of national importance and also permits the release of larger parcels for general commercial business. The orders in hand require the maximum production of all plant in operation and still larger imports of materials from the United States will probably be necessary. Increasing use is now being made of native ironstone, and consumers of imported ore have fairly good stocks to draw upon.

Cleveland Iron Trade.—Adequate supplies of foundry iron are reaching consuming works regularly, notwithstanding the limited supply of Cleveland pig, the intermittent make of which contributes little to current requirements. Most of the iron passing into ordinary use in this area is from the Midlands, but satisfactory supplies of certain qualities needed for particular purposes are coming to hand from elsewhere. Business passing through merchants' hands has increased, but is still by no means large. The stabilised prices of Cleveland pig remain at the equivalent of No. 3 quality at 128*s.*, delivered to the Middlesbrough district.

Hematite.—In the hematite department of industry, the increased use of American iron continues to relieve the pressure for supplies of local brands, the delivery of which has, however, improved appreciably. The bulk of the make is still absorbed by the heavy and increasing needs of the producers' own consuming plants. Second-hands are now able to obtain sufficient tonnage to cover the actual requirements of their regular customers. The delivery obligations of makers are still too heavy to permit the acceptance of much new business. Official quotations, both for East Coast brands and American hematite, are based on No. 1 description of iron at 138*s.* 6*d.*, delivered to North of England customers.

Basic Iron.—The requirements of the steelmaking plants owned by basic-iron producers absorb so much of the output from the blast-furnaces that no tonnage can be spared for the market. With no business passing, the basic iron quotation of 120*s.* 6*d.* is nominal.

Blast-Furnace Coke.—Little effort is made to put through transactions in Durham blast-furnace coke. Supply is plentiful, but holders are well sold and local users have little occasion to buy. The price of good medium qualities stands at 35*s.* 6*d.*, f.o.r.

Manufactured Iron and Steel.—Semi-finished and finished iron and steel works are operating at full capacity, and, together with the substantial and increasing imports, are able to meet the essential current needs. Ample quantities of semies continue to reach the re-rolling mills. The distribution of plates, angles, etc., is sufficient to keep the shipbuilding yards actively employed. Soft steel billets are quoted at 12*l.* 5*s.*; hard billets at 13*l.* 12*s.* 6*d.*; joists and sections at 15*l.* 8*s.*; heavy plates at 16*l.* 3*s.*; and heavy rails at 14*l.* 10*s.* 6*d.*

Scrap.—There is considerable activity in iron and steel scrap. Users have substantial stocks, but are readily accepting deliveries against running contracts and are anxious to negotiate for forward supplies. Among the principal market quotations for delivery to the North East Coast are:—Cast-iron borings, 46*s.* 3*d.*; heavy cast iron, 77*s.* 9*d.*; heavy mixed scrap, 70*s.* 3*d.*; heavy steel scrap, 72*s.* 3*d.*; bundled steel cuttings, 65*s.* 3*d.*; and heavy steel trimmings, 53*s.* 3*d.*

THE ROYAL GOLD MEDAL FOR ARCHITECTURE.—On the recommendation of the Royal Institute of British Architects, His Majesty the King has signified his approval of the award of the Royal Gold Medal for Architecture to Mr. Frank Lloyd Wright, the eminent American architect.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, January 11, 1.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Electrical Wiring Regulations and Their Application," by Messrs. E. H. Whatton and T. Hall. *Midland Section:* Saturday, January 11, 3 p.m., The James Watt Memorial Institute, Birmingham. Ordinary Meeting. "Some Problems of Electricity Distribution," by Mr. Donald Birch.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, January 11, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Woodworking Machinery: Recent Developments in Design," by Mr. R. H. Buckley.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, January 11, 3 p.m., The Engineers' Club, Albert-square, Manchester. "Sands," by Mr. W. Y. Buchanan. *Scottish Branch:* Saturday, January 11, 3 p.m., The Royal Technical College, George-street, Glasgow. "Apprentices and Foundry Planning," by Mr. James Arnott. *Lancashire Branch, Burnley Section:* Tuesday, January 14, 7.30 p.m., The Burnley Municipal College, Ormerod-road, Burnley. "Some Interesting Small Problems," by Mr. A. Jackson.

BRADFORD ENGINEERING SOCIETY.—Monday, January 13, 7.15 p.m., The Technical College, Bradford. "Reinforced Concrete," by Mr. G. McLean Gibson.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 14, 2.30 p.m., The E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. General Meeting. (i) "The Fundamental Principles of Vision in Very Weak Light," by Dr. W. D. Wright. (ii) Report on "War-Time Street Lighting and Aids to Movements in Streets—A Study of Fundamental Requirements."

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, January 14, 2.30 p.m., The Geological Society's Rooms, Burlington House, Piccadilly, W.1. Joint Meeting with *The Chemical Engineering Group* of THE SOCIETY OF CHEMICAL INDUSTRY. "Modern Developments in the Design of Plant for the Concentration of Sulphuric Acid," by Mr. P. Parrish.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Scottish Centre:* Tuesday, January 14, 6.15 p.m., The Royal Technical College, George-street, Glasgow, C.1. Informal Discussion on "Electrical Contracting, Including Some Aspects of Transmission Line Construction," to be introduced by Mr. H. M. Speirs.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 14, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "District Heating," by Mr. D. V. H. Smith.

ROYAL SOCIETY OF ARTS.—Wednesday, January 15, 1.45 p.m., John Adam-street, Adelphi, W.C.2. "Women in Industry," by Miss Caroline Haslett.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* Wednesday, January 15, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "Poppet Valve Steam Engine," by Mr. W. G. Brown. *Institution:* Friday, January 17, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. Lecture: "Optical Instruments, Particularly Large Astronomical Telescopes," by Mr. G. E. Manville.

UNITED STATES COLLIERY INDUSTRY.—The production of bituminous coal in the United States, during the week ending December 14, 1940, averaged 1,633,000 tons daily, compared with 1,637,000 tons in the preceding week and 1,445,000 tons in the corresponding week of 1939.

ROYAL SWEDISH ACADEMY FOR ENGINEERING RESEARCH.—Gold Medals of the Royal Swedish Academy for Engineering Research were presented to four Swedish engineers at the annual meeting of the Academy, held recently in Stockholm. The recipients were Messrs. G. Betulander, Knut Kaell, H. Spiegelberg and Sten Qvarfort, the first two receiving the award for their work in connection with automatic telephony. Mr. Spiegelberg was awarded the medal for long and meritorious work in the field of gas welding, while Mr. Qvarfort, who is technical officer of the Stockholm Gasworks, received the award for long continued research on coal and coke. Other awards include that of the Brinell Gold Medal to Professor Martin Wiberg for his work in connection with the use of electricity in steelmaking, and that of the De Laval Silver Medal to Messrs. Axel Svedlund and Lennart Cassler for their researches relating to the adaptation of producer gas for driving motor vehicles.

AMERICAN MARINE DIESEL ENGINE DEVELOPMENT.

(*For Description, see page 23.*)

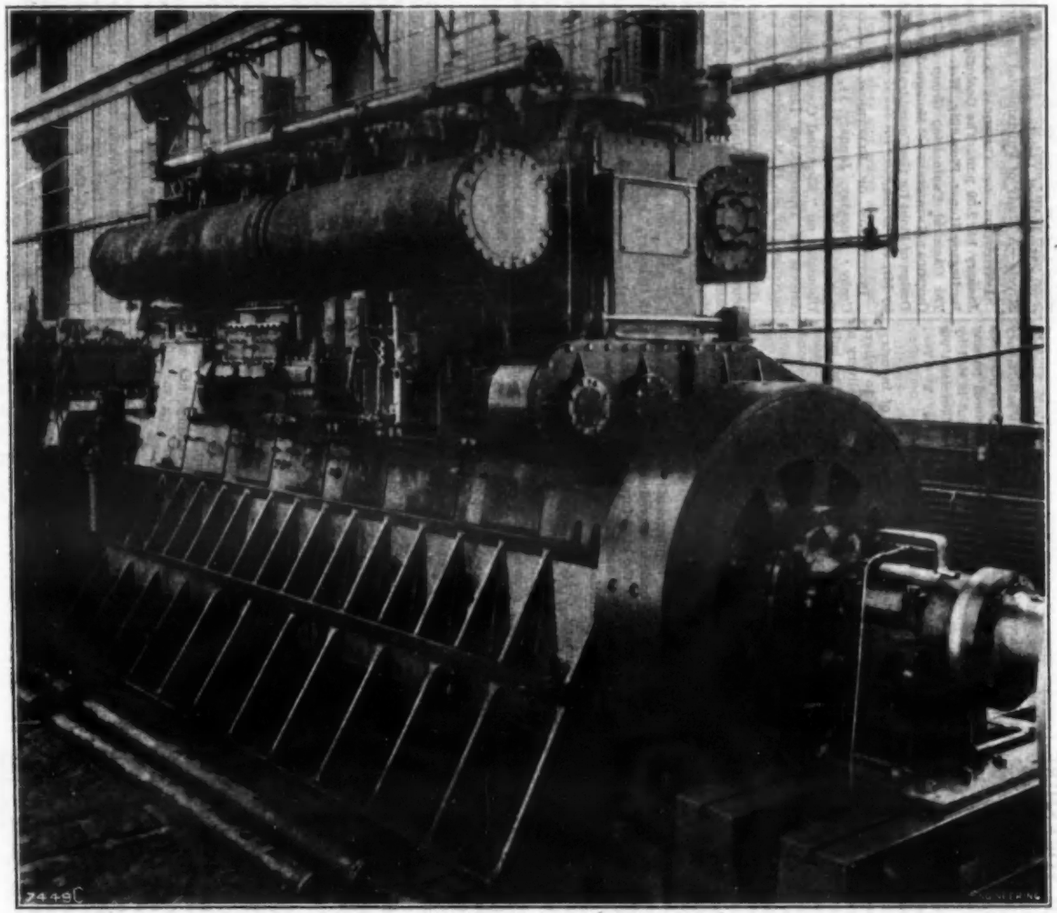
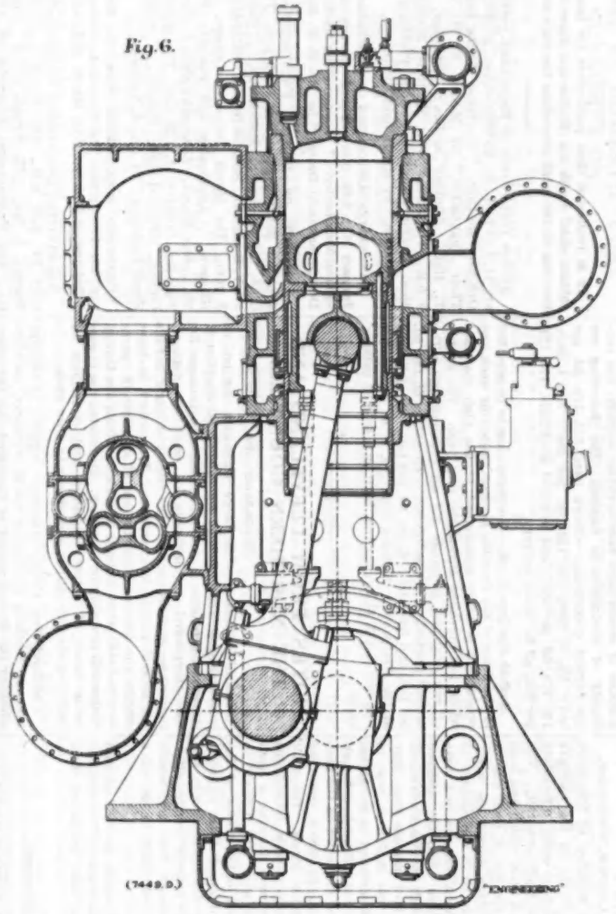


Fig. 5. 2,250-B.H.P. Busch-Sulzer Engine.

Fig. 6.



PRODUCTION OF TIN IN MALAYA.—The output of metallic tin and of tin ore, containing 75·5 per cent. of the metal, in Malaya, totalled 6,845 tons in November, 1940. Of this total, the Federated States were responsible for 6,574 tons; the Unfederated States for 253 tons; and the Straits Settlements for 18 tons.

MOONLIGHT CALENDAR FOR 1941.—Messrs. The Rawlplug Company, Limited, Rawlplug House, Cromwell-road, London, S.W.7, have sent us a copy of their "Moonlight Calendar" for 1941. The calendar takes the form of a small pamphlet, each page of which represents one month. The data are in the form of graphs, the days of the month being plotted as abscissæ and the hours of each day as ordinates. A clear white square indicates hours of bright moonlight, while shading indicates that the moon is up but not very bright. As the brightness increases the shading becomes lighter. Upper and lower strips, tinted yellow, indicate the hours of sunset and sunrise.

CONTROL OF DIAMOND DIES.—In pursuance of Regulation 55 of the Defence (General) Regulations, 1939, the Minister of Supply has issued an Order entitled the Control of Diamond Wire-Drawing Dies (No. 1) Order, 1940, which came into force on January 1, 1941. This Order provides that no person shall acquire mounted or unmounted diamond wire-drawing dies except from the Minister of Supply, or under the authority of a licence or special or general direction issued by him, and that no person shall dispose of such dies except to the Minister or to a person who is authorised by him to acquire them. The Order further provides that no person shall produce such dies except under the authority of a licence or special or general direction issued by the Minister. Further information may be obtained from the Diamond Die Control, 31, Albert-street, Rugby (Telephone, Rugby 3321). Copies of the Order may be obtained, price 1*d.*, from H.M. Stationery Office, York House, Kingsway, London, W.C.2, or may be purchased through any bookseller.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
The Determination of Hydrogen-Ion Concentration (*Illus.*)	21
American Marine Diesel Engine Development (*Illus.*)	23
Notes on New Books	25
Paraffin Washing Equipment (*Illus.*)	26
18-in. Centre Motor-Driven Break Lathe (*Illus.*)	27
Economy in Domestic Coal Consumption	28
British Standard Specifications	28
Personal	28
Tenders	28
Notes from the South-West	29
Notes from South Yorkshire	29
Notes from the North	29
Notes from Cleveland and the Northern Counties	29
Notices of Meetings	29
Education for Engineers	31
Exports	32
Notes	33
The Institution of Gas Engineers	33
Research on Refractory Materials	34
Letter to the Editor.—Solvent Extraction of Oil	36
Obituary.—Mr. W. Cruickshank. Mr. W. T. Calderwood	36
Rear-Admiral G. W. Melville, U.S.N. (1841-1912)	36
The Institution of Electrical Engineers	37
Labour Notes	37
The Physics of Steam Generation (*Illus.*)	38
"ENGINEERING" Patent Record (*Illus.*)	40

Two One-Page Plates.—6,000-B.H.P. SUN-DOXFORD MARINE DIESEL ENGINE.

ENGINEERING

FRIDAY, JANUARY 10, 1941.

VOL. 151. No. 3913.

EDUCATION FOR ENGINEERS.

FROM the nature of the profession for which it is a preparation, engineering education should be protean in character. There have been a number of indications in recent years that the need to avoid too narrow a specialisation in engineering training has not entirely escaped the notice of those engaged in imparting it or in directing the subsequent activities of the supposedly trained; cases in point are the chairman's address of Professor S. Parker Smith to the Scottish Centre of the Institution of Electrical Engineers, a year ago, and that of Mr. J. Taylor Thompson to the Yorkshire Association of the Institution of Civil Engineers, at about the same time. It is common knowledge, too, that, but for the outbreak of the present war, the whole question would probably have been subjected to a critical examination under the ægis of the leading engineering institutions. When peace is restored, it is inevitable that these problems will again come into prominence, with the added certainty that they will be illuminated, in the minds of many of the leading engineers of this country, by a more intimate acquaintance than has ever existed before with the methods, mental processes, and finished products of the nations of North America. It is interesting, therefore, to observe that even in the United States, with its lavish equipment of technological educational centres, there persist differences of opinion on the subject of engineering training which indicate much the same searchings of mind that are being experienced by thoughtful men on this side of the Atlantic.

The general challenge to the champions of contentment with things as they are seems to originate there, as here, with a feeling that the average engineering graduate is at once too narrowly, and insufficiently, educated; too narrowly, because his technical education is commenced too early, and insufficiently, because it is not continued long enough. A good survey of the present position in the United States is contained in the latest report of a committee on curricula of the Society for the Promotion of Engineering Education, which was printed by the American Society of Mechanical Engineers in the October, 1940, issue of their journal, *Mechanical Engineering*. The report declared categorically the belief that engineering education should rest on a foundation of the science of humanities and social relationships rather than on the practical techniques of particular industries or occupations, and that the mastery of these techniques, given that foundation, should then not require more than four years' training. The broadening of its basis on these lines has been in process of development for some time, and the committee recommend that this should be continued.

A well-argued paper, by Mr. W. H. Carrier, written from the employer's point of view, and reproduced in the same issue, seems to endorse this opinion. Mr. Carrier considers that the chief objective of a technical education should be to train the student in logical thinking and to develop his creative imagination, the primary aim being towards the acquisition of power rather than the amassing of factual knowledge. Presumably, the term "power" is here used in the sense of ability to perform assigned tasks rather than in a political sense. Mr. Carrier also expresses the opinion that few engineering students have had a proper educational training in secondary schools, with the result that this defect has to be overcome in the first two years of a college course. This comment on the delay in starting strictly professional training supports some observations in the presidential address of Professor A. G. Christie to the A.S.M.E., an abstract of which appeared on page 123 of our 149th volume (1940). Dr. Christie remarked on the fact that the present curricula of engineering schools devote much time to fundamentals as embodied in mathematics and the sciences, and to cultural subjects.

The authors of these two addresses, however, differ from the committee's report in appearing to consider that the first two years of a degree course could be better employed, but all three seem to be agreed in the view that these courses are not wholly satisfactory. It is necessary to bear in mind that the engineering schools and colleges in the United States are immensely more varied in method and structure than the corresponding establishments here. Direct comparisons between the two systems, therefore, are only of limited value. With the universities, however, there is not so much difference, and, in this respect, the committee's views may be of some interest. The report recommends that some of the advanced technical subject-matter now included in undergraduate curricula should be transferred to the post-graduate period, where it may be pursued with a rigour consistent with preparation for engineering specialisation. Dr. Christie was more emphatic: indeed, his remarks seemed to imply that the degree of bachelor in engineering was of little value, generally speaking, since he advocated a process of somewhat drastic weeding out as essential, only the survivors of that process proceeding to the higher degree, which, apparently, he regarded as chiefly furnishing useful material for industry. He instanced, as a parallel case, the training of doctors of medicine, observing that the best medical schools required not only a bachelor degree for admission, but a rigid appraisal of the applicant's possibilities as a practitioner. Industry should demand, he thought, that doctors of engineering should be as carefully selected and as thoroughly trained as doctors of medicine.

Mr. Carrier argues on much the same lines, and holds that the turn-over in employment of young engineers is altogether too great. The employer can obtain some idea of the personality of the student from an interview, but must rely wholly upon the young graduate's standing at his college in appraising his mental ability. To-day, he comments, a student's standing, as evidenced by his "marks," merely indicates his ability to memorise facts and formulæ, and does not disclose his ability in perception and reasoning, which is one of the characteristics in which the employer is chiefly interested. The marks, required indiscriminately, to secure a pass at present, are stated to be 60 per cent. Mr. Carrier suggests two "final" examinations, the first, with an 80-per cent. minimum, to test the thorough understanding of essential principles, while the second, with a 60-per cent. minimum, should test factual knowledge and facility

in engineering calculations; a proposal which is based upon the principle that the man who does not understand what he is doing will never make an engineer. What constitutes an engineer, however, cannot be rigidly defined in relation to industry; some forms of training may prove very suitable for particular industries and yet fail completely when applied to others. At first sight, the two examinations might appear to be equivalent to the two parts of the final engineering degree examination of the University of London; but, in reality, the order is reversed. The first part of the London final is more or less general, while the second, and stiffer, part is highly specialised.

In connection with specialisation, Mr. Carrier makes the statement that, in the United States, probably 90 per cent. of the students do not, in after life, follow the field in which they have specialised at college. In other words, 90 per cent. of the time and effort spent in specialisation, except as far as it may be useful as training in the application of fundamentals and in thoroughness, is wasted. In Dr. Christie's opinion, specialisation should be confined to post-graduate study, but graduate training should extend over sufficient time to give a man that independence of thought and action which enables him, without the guidance of others, to develop his own problems and to proceed to their solution. This competence, however, develops only slowly in the average man. Dr. Christie was less definite in discussing the training given to graduates when they have actually entered industry. Industry in general, in his view, is expected to find a place for the man with a bachelor's degree, as well as for the man with advanced training, and to train each man to be of the greatest benefit to himself and to the organisation concerned. Too often, in such training periods, he added, there was a tendency to shorten the time spent in the shops or over a drawing board. This curtailment may be partly due to the graduate himself who is frequently impatient and desires promotion before he has gained the necessary experience. Dr. Christie blamed the colleges for giving their students an exaggerated idea of their value to industry; but he recommended an ample rate of pay for graduates, arguing that, although they might not earn it, this expense to industry was part of the price that must be paid to secure ultimately a competent staff. Mr. Carrier hardly touches upon this point of industrial training, his paper being mainly an indictment of present educational conditions, which, he seems to think, impose an undue burden on the employer. He declares roundly that industry has no use for "duds," and that the preliminary sorting can be done most soundly and economically at the engineering college.

The report does not deal in detail with either post-graduate education or industrial training but, towards its conclusion, stresses the pruning of existing courses with the aim of strengthening the undergraduate programme as a preparation for subsequent professional development. Greater concentration of effort upon the mastery of fundamental concepts and the cultivation of the intellectual powers required in the more extended use of engineering methods, it is suggested, would provide a more effective base for advanced scientific study, so rendering the graduate more sensitive to the lessons of practical experience. In its concluding sentence, however, the report urges that "no measures taken with respect to engineering education should limit the freedom that now exists for experimentation and change." With this conclusion there can be no serious disagreement; and if it should induce a doubt as to the utility of these recurring discussions on engineering education—as well it may, since the fitting of most engineers into their ultimate niches still seems to depend more upon accident than design—the fact must still be borne in mind that engineering itself is always in a state of flux. It is probably true to say, however, that in no other profession have the lessons of the past been so well learned; and it is only reasonable for practising engineers to concern themselves to see that the training of newcomers to the profession is not undesirably stereotyped, on lines which are liable to become progressively divergent from the needs of the present and the probable future.

EXPORTS.

THE shipping difficulties which are restricting supplies of bananas and apples leave export facilities relatively unaffected. The mercantile craft which have been diverted to war services in Mediterranean and other waters are certainly temporarily lost to the service of trade, but the large fleet still employed in bringing food and other supplies to this country provides plenty of capacity for export goods, especially as, apart from coal, these are usually of a less bulky type than many of the materials which are being so largely imported. The unavoidable delays imposed by the assembly of convoy fleets, and other inconveniences and uncertainties, may hamper exporters, but, broadly speaking, there is no shortage of shipping space. This is fortunate in view of the necessity for cultivating exports in order to conserve Britain's international financial position. This necessity is fully understood, and, as most people have directly realised, the home market is being deliberately kept short of various commodities in order to supply the export markets.

It is unfortunate that this wise policy is meeting with certain difficulties, some of them, perhaps, unforeseen. This applies particularly to export trade with the United States, the importance of which, in view of the present enormous imports of war material from that country, give it first place. The United States tariff laws require the duty that must be paid on goods imported into that country to be calculated in terms of the retail selling price in the country of origin. This is a quite understandable outcome of the anti-dumping legislation. Unfortunately, the imposition of the purchase tax in this country has raised the retail price of most goods to an artificial level. Consumers here understand the purpose of this tax, and, in general, have accepted it without complaint. It is a different matter, however, if a proportion of the tax is also to be passed on to purchasers in the United States. This situation is already a serious handicap to exporters who are building up a trade with that country, and it is greatly to be hoped that, in view of the cordial relations existing between the two Governments concerned, some method of eliminating the difficulty may be found. Prior to the imposition of this tax, satisfactory progress was being made in fostering exports to the United States, and, although the new trade built up was very far from balancing the spate of war supplies now streaming across the Atlantic, it was, none the less, a useful contribution.

It is not only with the United States that British exporters are forming new trade connections. As is well known, there is now an important British trade commission in South America, which should do much to expand the already important volume of our exports to that continent. Within the Empire, preferences and mutual interest are consolidating an already strong position. Even in China, which, during years of war, has never ceased to be a valuable customer, present conditions should help us. Nearer home, things are naturally difficult, but with Turkey in particular we should be able to increase our trade greatly. The difficulty in this case is in arranging for the shipping of the material that Turkey desires to sell to us in exchange for the manufactures she is willing to buy. This situation is being greatly eased by the financial arrangements made by the United Kingdom Commercial Corporation, which also concerns itself with the reservation of shipping space.

Probably rightly, the main concern of the Government is to foster export trade and maintain financial stability, but the manufacturer and trader may well take a longer view and look upon the present time as a favourable opportunity to take over trade connections formerly existing between Germany and other countries, which have now been severed. Much of the manufactured material which Germany supplied, British manufacturers can supply equally well; and, any higher motive apart, it is but ordinary commercial prudence to endeavour to take advantage of a market in which the former suppliers have gone out of effective existence. The opinion about the present rulers of Germany, which is generally prevalent throughout the civilised world, is likely to prove a valuable asset in this cultivation of new customers. It was during the war of 1914-18 that Japan laid the foundations of her strong trade position in India and other eastern countries. Supplies from the combatant European nations ceased and Japan seized the opportunity to enter a market from which, *pro tem.*, other competition had disappeared. Our present condition is not exactly parallel with that of Japan in 1914-18. The greater part of our energies have now to be turned to the winning of a stern war. Japan was in no such position, but could give full attention to commercial matters. Technically, she was a combatant, but her actual part in the war was over in the early years. This made the task of the Japanese exporter easier, but that is no reason why, in more difficult circumstances, British traders should not do all that they can.

It is particularly in South America that present conditions should provide a golden opportunity, as has been repeatedly pointed out in our recent series of articles on South American trading conditions. In various ways, some of them devious, Germany had established trade connections there which, in normal times, might have proved difficult to break. With Brazil, for example, she had a barter arrangement under which engineering and other manufactured goods of all kinds were exchanged for coffee, Brazil's main export. As the bargain struck is obviously moribund, the time is particularly favourable for others, who are in a position to implement their word, to step in and establish connections which may endure when the present abnormal conditions have become a matter of history. Even in the throes of what we may pray is Armageddon, it is well to take thought for the future.

The proper cultivation of new markets involves the dispatch of competent representatives, the establishment of overseas stocks, the granting of long credits, advertising in foreign journals, and various other measures which to-day either cannot be undertaken at all, or can be initiated only on a minor scale. This, however, is no reason why preparations should not be made for a more active policy when present troubles are ended. There are many overseas markets, which, hitherto, have not been extensively cultivated by us, and many manufacturers who have not given much attention to overseas trade, and the present is the time when future possibilities may usefully be studied. It would be unwise to leave all preliminary work until the post-war competition sets in.

To those who realise the importance of learning all they can of overseas markets, a recent book, *Money in Exports*,* by Mr. Walter Buchler, may be recommended, as it reviews most overseas markets and gives just the type of information that an exporter requires. It is in the nature of a text-book, and is all the better for that; books on this type of subject are apt to prove to be essays in general terms. Mr. Buchler, however, indulges in no generalities. Dealing with each country in turn, he explains the extent of the possible market, the class of goods purchased, the type of agent desirable, and the method of ascertaining his standing, financial and otherwise, the time required for a personal survey of the field, the language or languages employed in commerce, and the many other local conditions on which the success or failure of a selling campaign may turn.

The book is not particularly concerned with engineering matters, and, as it points out in the appropriate places, most of the large engineering firms have already established branches or associated companies in the more important markets. Even in these cases, the information about local advertising, the status of merchants, etc., may prove of considerable value, but it is probably in the field of consumption goods that the book will prove most valuable. Many of these goods are important engineering manufactures: motor cars, wireless sets, carpet sweepers, typewriters, domestic refrigerators and fans are cases in point. In the aggregate, manufactures of this type constitute an enormous industry. In many spheres, the overseas sale of articles of this class has not been cultivated by this country to anything like the extent as it has been by Germany, and if Mr. Buchler's text-book does anything to improve the position it will have served its purpose well.

* London: Useful Publications (Price 10*s.* 6*d.* net.)

NOTES.

ACCELERATING IMPORTS AND PRODUCTION.

ARRANGEMENTS by which, it is hoped, the complicated procedures of government in war time will be brought into a more simple and closely-knit structure were announced from Downing-street at the beginning of the week. This reconstruction will reduce the number of subsidiary committees and the time spent in attendance upon them, enabling more rapid and decisive action to be achieved. Briefly, an Import Executive has been formed consisting of the five ministers—the Minister of Supply, the Minister for Aircraft Production, the First Lord of the Admiralty, the President of the Board of Trade, and the Minister of Food—who are the chief importers at the present time. The duty of this body will be to "animate and regulate" the whole business of importation in accordance with the policy of the War Cabinet. The Minister of Transport, the Minister of Shipping, the Merchant Shipbuilding and Repair Branch of the Admiralty, and other Ministries or Departments concerned will render all necessary aid to the Import Executive in executing and implementing their decisions. The Minister of Agriculture will also have ready access to the Import Executive, while the President of the Board of Trade will represent the interests of the lesser importing departments. In addition, a Production Executive has been set up, consisting of the Minister of Labour and National Service as chairman and the Minister for Aircraft Production, the First Lord of the Admiralty, the President of the Board of Trade, and the Minister of Supply as members. This body will be principally concerned with the allocation of available sources of raw materials, productive capacity and labour, together with the fixing of priorities where necessary. It will take the place of the Production Council. The existing Committee of three Supply Ministers, which regulates and concerts purchases in North America, will continue its separate work. The work of the two new Executives, as well as of the three existing committees on civil defence, home policy and food policy, will continue to be directed by a committee consisting of the chairmen, over which the Lord President of the Council will preside. This body will advise the War Cabinet on the progress of business in the executives and committees and will also deal with the general issues of economic policy formerly considered by the Economic Policy Committee.

A POLICY OF RECONSTRUCTION.

While the new bodies to which reference is made in the previous paragraph are concerned with the more vigorous conduct of the war in its various phases, the claims of post-war reconstruction are not being forgotten. The official statement on this question announces that the Minister without Portfolio (Mr. Arthur Greenwood), has undertaken responsibility for the study of reconstruction and post-war problems. Later, when the end of the war can be more clearly foreseen, a Ministry will be formed for the purpose. Meanwhile, the object of the committee will be to find practical solutions to the immediate problems of transition from war to peace, and also to outline and presently to amplify a policy for the years immediately following the war which will command the support of the nation as a whole and enable united action to proceed in peace as in war. Though, naturally, this work must not take precedence over more warlike efforts, it is as well that it should be undertaken, especially as peace may "break out" with the same suddenness as war. When that occurs a whole crop of fresh problems will immediately arise and it would be well for their implications and possible solution to be considered well in advance. The result of the opposite policy may be illustrated from what occurred at the beginning of the war, when it was quickly shown that many problems of both a technical and non-technical character—air-raid shelters, transport, evacuation, street lighting, food supply, among others—had not been sufficiently considered, with the result that in some the compulsion applied was found to be too drastic while in others the machinery broke down simply because its design was misconceived.

CENTRIFUGAL PUMPS IN COLLIERIES.

Some recent applications of centrifugal pumping machinery formed the subject of a lecture, which was delivered at Cardiff before the South Wales branch of the Association of Mining Electrical Engineers by Mr. R. E. Fortune. The lecturer said that, in his opinion, the average electrical engineer of a colliery company was more ready to appreciate the value of the fundamental theoretical considerations than his mechanical colleague. There was also a growing tendency to entrust to the electrical engineer the choice of pumping plant, which was essentially a combined electrical-mechanical unit. A possible explanation might be that technical electrical thought was peculiarly akin to pump design. A failure or breakdown, inconvenient as its results might be, should provide an opportunity for trouble diagnosis. The differences between the centrifugal pump of thirty years ago and its modern counterpart were small, but they existed. They were due to methods of manufacture, the results of competition and also of metallurgical research. Output for output, the modern pump was lighter and ran at a higher speed, and for factors of ignorance there had been substituted more or less well-known factors of safety. If there had been a tendency towards "slimming" to meet the voracious appetite of the price buyer, it could be truthfully said that the metal was better placed and of superior quality. The conservative attitude of the mining engineer was and still remained easily explicable. The safety of the mine was his first and only consideration. Courageous pioneering might, in his case, sometimes be termed foolhardiness.

BRITISH RAILWAYS IN 1940.

An official statement, recently issued, describes how British railways are withstanding the stress of war and illuminates certain high spots which not only mark past endeavour, but teach lessons for the future, which will, we hope, be duly appreciated. At the beginning of 1940, the Service Departments made great demands upon the railways, and special trains for the conveyance of troops and equipment were run at the rate of 2,300 a month. Nature also took a hand in adding to the congestion when, towards the end of January, 1,500 miles of line were blocked with snow, and scores of trains were snowed up, hundreds of miles of telegraph and telephone wire were brought down and points and conductor rails became affected by ice. Some 300 snowploughs were used to effect a clearance. A few weeks later, passenger services on certain lines had to be restricted to enable more coal trains to be run to make up the shortage caused by the severe weather and by the defects in the arrangements for distribution. Over 2,000 special coal trains had been operated by the end of June, by which date it was possible to resume more normal working. In the meantime, the extra passenger trains scheduled to run during the Whitsuntide holiday were cancelled owing to events in Holland, their place being taken by special trains for evacuees both from our own cities and from the invaded countries. Similarly, aliens and prisoners of war had to be transported. The peak of special traffic was reached, however, when the evacuation from Dunkerque necessitated the running of 620 trains in eight days to carry 300,000 troops. At the busiest time, 100 trains were worked in 24 hours. When the war in the air began in August, the railways suffered their share of damage, first in the coastal districts, and later in London and elsewhere. Emergency repair services had to be organised, and, in London, alternative methods of transport, such as 'buses and temporarily, river steamers, were put into service. The black-out every night and the air raids, at times slowed down the traffic with resulting delays, which were borne as philosophically by passengers as their temperaments allowed. A financial agreement was tentatively entered into with the Government, but it was not fully implemented and its principal result has been to increase the cost of travelling. Relations with the public have been somewhat strained at times, but there appears now to be a more general appreciation of the difficulties that have had to be faced.

THE INSTITUTION OF GAS ENGINEERS.

(*Concluded from page* 16.)

THE Joint Lighting Committee point out that, by the recommendations of the Fifth Report on Lighting in Factories, the war-time practice of persons working more than 48 hours per week involves the installation of a considerably higher standard of interior illumination than previously; owners of factories having gas lighting have been informed that advice on this matter may be obtained either from the local gas undertaking or on application to the secretary of the Joint Lighting Committee of the Institution of Gas Engineers. The booklet *Light on Industry*, issued by the British Commercial Gas Association, in collaboration with the Joint Lighting Committee, has been brought up to date by the issue of an addendum entitled *Light on Production*, dealing with the recommendations in the above-mentioned Fifth Report.

The Liquor Effluents and Ammonia Committee have recommended that a full-scale trial should be made of the process devised by their research chemist, Dr. A. Key, for the production of ammonium bicarbonate as an alternative to ammonium sulphate. In view of war-time conditions, Mr. H. J. Hodsman's process of washing furnace or flue gases with crude or concentrated liquor, for the production of ammonium salts suitable for use as a fertiliser, has been considered.

The Pipes Committee have made certain recommendations to gas undertakings consequent upon the cessation of manufacture, for the period of the war, of normal heavy-weight tubing (steam quality) used in the gas industry. It is pointed out that connectors, connector bends and similar parts, with parallel threads, will be supplied in heavy-weight tubing; and, as the adoption of light-weight tubing will reduce appreciably the margin of strength in service pipes, particularly on the screwed portions of the pipe, they stress the need for supporting the pipes and protecting them by troughing.

Examination of a badly corroded wrought-iron bend led to the conclusion, from the present known work on corrosion, that, while fatigue of the metal due to straining does not affect its susceptibility to corrosion, there is a possibility that bending may cause the opening of invisible pores in the metal on the outside of the bend, with the result that corrosion may become localised at that place. Examination after 30 years of use of a mild-steel gas main with wrought-iron service pipes indicated that with effective protection against rusting there seems no reason why mild steel services should not give satisfactory results.

As the result of the severe weather experienced in the winters of 1938-39 and 1939-40, and the number of cases of fractured mains and service pipes reported, the Pipes Committee have investigated the relationship between the incidence of low temperatures and the fracture of mains and service pipes. It is known that low temperatures have little effect on the static properties, such as tensile strength, of mild steel and cast iron; on the other hand, when low temperatures occur, if the provision for contraction is insufficient, mild steel will yield under the resulting tensile stresses without cracking, but cast iron will be liable to fracture without appreciable yielding. An analysis of the replies to a questionnaire on the subject showed generally that, during the cold weather, the greatest number of fractures per 100 miles of main occurred in 3-in. mains, and that the majority of the fractures were located at service connections. In some cases, there appeared to be a close connection between the number of fractures recorded and the ground temperatures at depths of 1 ft. and 4 ft. Little influence on liability to fracture could be attributed to material, age or corrosion of mains, positions of mains in regard to depth, whether they were laid under footways or carriageways, or to other external agencies. Any penetration of frost must impose loading on the underlying subsoil, as upward expansion is restricted by the solidity of the reinstated surface of the road or pathway and by the rigidity of the frozen upper layer of earth.

RESEARCH ON REFRACTORY MATERIALS.*

Of the long report that has been issued by the Refractory Materials Joint Committee of the Gas Research Board and the British Refractories Research Association, a great deal is occupied with five papers on refractory insulating materials. Three of these papers are concerned with the production of dry-pressed materials of improved or specialised characteristics, and the remainder with the important subject of testing. The work was the outcome of a request from the Gas Research Board that special attention should be given to refractories for gas- and coke-burning appliances, but the subject is important, of course, to all fuel-using industries. On firing mixtures of pulverised coal and fireclay, highly-porous grog of fine texture is produced which, bonded with additional clay and coal, shaped by the dry-press process, and fired, can give refractory insulating material of improved characteristics. By a development of the process, full-size refractory insulating bricks have been produced having a relatively dense and slag-resisting face.

The report points out that there is great need of further improvement in the field of insulating firebricks, the prime function of which is to replace ordinary firebricks in positions where heat losses may be reduced and, especially, in contact with the furnace gases. In particular, their resistance to sudden changes of temperature, overheating, abrasion, and the cutting action of flames, as well as to slag attack, should be increased. At the same time, their cost must not be increased to an uneconomic point. The aim of this research was to meet these demands. Two features which cause trouble in the manufacture of clay insulating firebricks, in which a combustible is burnt out, are the control of the temperature during the oxidation period, and the prevention of warping and twisting by over-firing. The first can be overcome by firing a few insulating bricks on top of the usual setting, and by other means. The second can be prevented by keeping the finishing temperature rather low (which will reduce the maximum safe temperature of use) or by cutting to shape after firing. Both these difficulties can be avoided by dry-pressing a grogged batch of the kind to be described. Dry-pressing has the further advantage that the bricks are made up true to size, because the drying and firing contractions are small, and the grog can have a high porosity which is independent of the grog size; the greater strength of dry-pressed units enables them to be handled more easily. The disadvantages of dry-pressing are that the thickness that can be uniformly pressed is restricted, that the process calls for separate preparation and firing of the grog, and that the number of shapes economically possible is limited by the cost of the moulds.

In the preliminary work, a Stourbridge fireclay, ground to below 100 mesh, was mixed with pulverised coking coal of even greater fineness. Investigations upon the ratio of clay to coal indicated that bulk density and cold-crushing strength decreased with increasing coal content, while the linear contraction increased rapidly at high coal contents. The bulk-density values were rather high, and more than 60 per cent. of coal would be required to reduce the value to below 60 lb. per cub. ft., while the best commercial insulating bricks, intended for use up to 1,400 deg. C., do not exceed 50 lb. per cub. ft. The necessity for producing a grog with an adequate cold-crushing strength caused the coal content to be fixed at 40 per cent; above this the cold-crushing strength falls off rather rapidly. The firing temperature is important. It was intended to fire the brick at 1,400 deg. C., but, in experiments made at lower firing temperatures, it was found that the firing contraction, the bulk density, and the crushing strength were all diminished at the lower temperatures, this effect being more marked as the proportion of coal was increased. Some reduction in bulk density may be produced by eliminating the finer clay fraction. It was found that, in moulding a shape from the porous grog, pulverised coal and clay, much depends on the method of making, whether by hand-moulding or by machine-pressing. In bodies prepared with various proportions of grog and a clay bond containing 40 per cent. of pulverised coal, bulk density and cold-crushing strength are decreased with higher grog content when hand-moulding is employed, but the opposite is the case with machine pressing. In making dry-pressed bricks, water contents of 5 to 10 per cent. are usual, but experiments with water contents up to 20 per cent. showed that the increasing plasticity developed as the water content rises increases slightly the total contraction, the bulk density, and the crushing strength by increasing the vitrification produced on firing. Since the heat losses by radiation across a space are diminished in proportion to the number of barriers which are introduced, manufacturers of insulating bricks aim at producing bricks having a large number of fine pores; this is accomplished in the present work by using material of extreme fineness. The experiments appear to show that, as the screen size of the fraction was diminished, the porosity decreased, but investigation of the porosity with decreasing grain size gave little indication of the distribution of pore sizes, though it presented a qualitative view of the fine structure of the system as a whole. In a large-pored material, the porosity of the crushed material diminished rapidly with decreasing grain size, while, in a material of extremely fine structure, little change should be evident until the smaller sizes are reached.

Following this preliminary experimental work, attempts were made to produce a dry-pressed grogged-clay brick with a slag-resisting face. Porous clay insulating bricks offer practically no resistance to molten slag and little to reactive solid particles striking the brick surface. This disability has hitherto limited insulating firebricks to backing-up purposes or to hot-face duty in high-temperature installations where the atmosphere has been almost free from corrosive dust particles. The heat saving made possible by the use of these bricks is greater, the higher the furnace temperature, but, unfortunately, the higher the temperature the more intense are the accompanying conditions of slag attack and heat shock. What is needed, therefore, is a constructional material resistant to these adverse agencies, and, at the same time, of low thermal capacity and conductivity. For furnaces in use for longer than, say, 24 hours without interruption, a lining of dense refractories, lagged with diatomaceous earth or porous clay bricks, can be used; but, for furnace operating on short cycles at temperatures of 1,200 deg. C. or above, where the rate of heating is rapid and scale, dust, etc., or even liquid slag are probably present, there has been no method of achieving high thermal efficiencies. The suggestion to combine in one brick a dense face and an insulating backing is worth continued investigation. Attempts of this kind have been described in the past, but, presumably owing to manufacturing or economic difficulties, have not been generally accepted.

Although the bricks described in the papers were composed wholly of clay, attention is being given to the use of other raw materials. In the main, the patented methods of producing these bricks, usually called "composite bricks" by analogy with "composite walls," call for unusual ways of making and firing. The method here described relies on devices which are standard save for the feed to the mould box. The product may, perhaps, be more appropriately termed a "graduated brick." Bearing in mind the poor adherence of coatings more than ¼ in. thick, it was decided to make the dense face at least ½ in. thick, and, as far as possible, of the same drying, firing and expanding characteristics as the backing. To obtain a good union between dense and porous zones, one or more intermediate zones, occupying about as much space as the dense face, were interposed. These, too, served to reduce the abruptness of the temperarure gradient. The dry-press method was adopted, pressure being applied to both of the 9-in. by 3-in. faces. Calculations made at an early stage showed that the first and second half-bricks of dense face added 18 per cent. and 15 per cent., respectively, to the heat capacity of a porous brick. From this it appears that the dense face should be as thin and light as possible.

The method used for forming the face was as follows:—The mixes were prepared by hand; then the dense-face batch was introduced into the mould and levelled off without any attempt at consolidation. The intermediate zone or zones were added in the same way, followed by the porous mix; at this stage, the contents of the mould could be rammed down. The superposition of the loose, semi-dry mixes ensured sufficient intermingling at the inter-faces to produce a strong union on pressing. Initial trials were made on blocks 3 in. by 3 in. by 2½ in., approximately, pressed from top and bottom simultaneously under a pressure of 1,250 lb. per square inch. Later, standard brick shapes, 9 in. by 4½ in. by 3 in., were made in the same way, but using a pressure of 2,500 lb. per square inch. The dense layer formed one of the 9 in. by 3 in. faces. Pressing was carried out in a hydraulic testing machine, in which the application of pressure was gradual and took place at a predetermined rate. The pressed shapes were strong enough to be handled without difficulty. The fundamental requirement for the success of the process is that the dense, intermediate and porous zones shall adhere without stress after firing. A grog content of 45 per cent., in both sections, yielded a block free from differential contraction of the zones. In addition to the stresses inherent in the imperfect matching of the zones, further stresses are imposed during use by the temperature gradients developed at the inter-face. When the dense face is exposed to a high temperature, there is a change in the temperature gradient at the intermediate zone, due to the insulating effect of the backing; this means that the dense face will expand, as a whole, more than the other zones. One method of reducing the sharpness of the temperature drop and the severity of the strain lies in an increase in the number of intermediate zones, so that the transition from dense to porous material is spread over a greater distance.

In a test of refractoriness under load, it was found that the porous back would not withstand the load so well as the dense face. There was very little contraction on reheating of a body containing 45 per cent. of well-fired grog, fired to 1,400 deg. C. Although there was no indication of imperfect union between the dense and insulating sections, it is obvious that internal stresses will be developed at the junction of these zones. A series of tests showed that, in commercial specimens, cracks originated in the heated faces and spread backwards; whereas, in the bricks made for this research, the heated face appeared to be unaffected, but one or more cracks developed in the back face, and advanced through the brick in subsequent cycles until rupture occurred. The bricks stood up well to a slag-resistance test. Tests upon the thermal characteristics of the bricks thus made gave the following results:—

	Fire-brick.	Composite Brick.	Insulating Brick.
Density, lb. per cub. ft.	114	67	46
Thermal conductivity (British units) at 450 deg. C. mean temperature	7·70	3·09	1·94
Time to rise from 100 deg. C. to 750 deg. C., minutes	100	78	77
Heat absorbed in heating to 750 deg. C., B.Th.U. per sq. ft.	5,610	3,030	1,860
Heat content of test slab at equilibrium, hot face at 750 deg. C., B.Th.U. per sq. ft.	8,300	4,500	3,070
Heat transmitted at equilibrium, hot face at 750 deg. C., B.Th.U. per sq. ft. per hour	1,500	700	470

It is considered that a reduction in the thermal conductivity is desirable. Not much diminution in the heat capacity of the graduated bricks is possible. The dense face cannot be made porous without losing slag resistance, neither, with present information, is it deemed advisable to reduce the thickness. The influence of the making pressure on the physical properties of a dry-pressed, grogged, clay insulating firebrick is treated in greater detail in a further paper in the series. The various properties examined —firing shrinkage, permeability, apparent porosity,

* *The 31st Report of the Refractory Materials Joint Committee.* London: The Institution of Gas Engineers.

bulk density and cold-crushing strength—change roughly in proportion to the distance from the face receiving the pressure. Thus, in a pressed brick, there is a median layer of less compact texture than the surface.

The first of the papers dealing with the testing of refractory insulating materials discusses the adequacy of the methods now in vogue. It is asserted that the requisite properties of high-temperature insulating materials are: sufficiently low thermal conductivity and capacity, permanence of shape and structure under working conditions, and adequate strength at ordinary temperatures. For this reason, importance is attached to the following determinations:—(*a*) thermal conductivity; (*b*) porosity and bulk density; (*c*) permeability; (*d*) contraction on reheating; (*e*) refractoriness under load; (*f*) spalling resistance; (*g*) resistance to the cutting action of flames and corroaive dusts; (*h*) resistance to carbon-monoxide attack; and (*i*) the crushing and transverse strength, cold. In the second paper, certain aspects of testing are examined with particular reference to the results obtained on a number of representative insulating materials. It is shown that a static compressive load of 10 lb. per square inch produces subsidence equal to the shrinkage on reheating at a temperature some 150 deg. to 200 deg. C. lower, when the amounts are of the order of several per cent. The temperature of failure in tension is considerably lower than in compression. Bulk density is a factor of considerable importance in determining resistance to load and to slag attack at high temperatures. Slag attack is aggravated by the opening of joints in brickwork by heat shrinkage. To obtain a representative value of the contraction on reheating, several bricks are needed, and test pieces cut from them require to be measured in three directions at right angles. An investigation into the effect of temperature on the crushing strength showed a maximum strength at about 975 deg. C. for clay insulating bricks.

The remainder of the report was devoted to a variety of subjects, more particularly of service in gas manufacture. In an interesting section upon the influence of the surface colour of refractory bodies on the rate of heating and cooling, it is pointed out that a study of the available data reveals wide discrepancies in the values of emissivity found for different pure oxides and refractories at different temperatures, which are best explained by the experimental difficulties attached to an absolute measurement. Experimentally it was found that, when a cold cylinder of refractory material is heated by insertion into a furnace at 1,000 deg. C., the rate of rise of temperature at the centre is influenced by the colour of the surface of the cylinder. On withdrawal from the furnace, the rate of cooling of the cylinder from 1,000 deg. C. is less dependent on surface colour. The colours fall in the order, black, brown, white, yellow, for both heating and cooling, black producing the fastest rate of heating and cooling, and yellow the slowest. A colourless glaze decreases the rate of heating slightly at first and then increases it. A glazed china-clay surface allows more rapid cooling than the same surface unglazed. Detailed curves given in the paper show that, when a cylinder coated with the proper layer of pigment (weighing about 200 times less than the cylinder), was inserted into a furnace already slightly above 1,000 deg. C., after four minutes a black cylinder had reached 730 deg. C., but a yellow cylinder only 577 deg. C., these being, respectively, the fastest and slowest rates of heating of any of the colours used. In cooling from 1,000 deg. C., after four minutes the black cylinder had fallen to 577 deg. C., and the yellow to 639 deg. C. This probably indicates that the thermal conductivity, or, strictly, the diffusivity, is of preponderating importance in cooling. The temperatures were measured at the centre of the cylinder.

The work on the action of alkalies on refractory materials has been continued in two directions. In the early reports, it was pointed out that disruptive forces of considerable magnitude might be set up through this action in high-temperature installations exposed to alkali-chloride vapour. Linear expansions up to as much as 4 per cent. have been recorded, due to exposure to the vapour of alkali chlorides, a definite chemical reaction taking place, involving the formation of sodium or potassium compounds. This growth is apparently uniform in all directions. A test-piece has been treated by several exposures to alkali chloride at a temperature of 1,000 deg. C., each exposure lasting several hours and being followed by cooling. Cracks developed in this brick and illustrated the conclusion already suggested by earlier work, that the expansion effect of alkali chlorides on fireclay products may have serious consequences under certain conditions. One of the conditions is temperature, for the available evidence points to the conclusion that at a higher temperature, such as 1,200 deg. C. to 1,300 deg. C., at which the alkali products of reaction would be liquid, stresses to cause similar rupture could not be produced in the softened material. In short, the phenomenon may be attributed to the ability of the fireclay to react to an appreciable extent at 1,000 deg. C. to form alkali compounds, but with very little liquefaction of the material of the brick. The alteration in transverse strength, measured at 1,000 deg. C., of various refractory materials after exposure to potassium-chloride vapour at 1,000 deg. C., was described and discussed in the 30th Report.* With the fireclay material, reaction with the sodium salts caused softening, but, with the potassium salts, embrittlement occurred.

Continuing with the study of the action of methane on refractory materials, described in the 29th Report, it has now been demonstrated that the minimum temperature at which susceptible firebricks are attacked by pure dry methane is between 600 deg. and 700 deg. C., and that the presence of moisture in the methane may considerably increase the resistance of firebricks to disintegration at 800 deg. C. This observation may be compared with that described in the 28th and 30th Reports, in which it was found that town gas, with its normal content of carbon dioxide, leads to disruption through the decomposition of the methane at the activated "iron spots" of the firebrick, according to the equation $CH_4 = C + 2H_2$. Further work has shown that the resistance of firebricks to disintegration by pure dry methane is dependent on their thermal history. A firebrick, normally susceptible to attack, was rendered inert by refiring to 1,400 deg. C. or to 1,300 deg. C. in a reducing atmosphere, for several hours. When this brick was fired in an oxidising atmosphere, its behaviour did not differ from that of the unfired specimen.

The occasional occurrence of significant amounts of chlorides in coal, notably sodium chloride, raises the question of the action of chlorine and hydrochloric acid on refractories when such coal is burnt or carbonised. Under oxidising conditions, chlorine will be liberated and, in the presence of steam, hydrochloric acid will be generated. Sodium chloride at 1,000 deg. C. can cause the volatilisation, to some extent, of certain constituents of refractory materials in a dry inert atmosphere, free from oxygen. The chlorides of iron, aluminium, calcium and magnesium were found among the volatilised products of reaction with fireclay and silica test-pieces. The manner and magnitude of the volatilisation was found to be modified, however, by the presence of oxygen or water vapour in the gases accompanying the chloride vapour. Further experiments have been carried out by leading dry chlorine over various refractory materials at 1,000 deg. C. A plumbago brick suffered the greatest loss, carbon dioxide and silicon tetrachloride being formed. A blue-brick clay was attacked markedly, and silica, sillimanite and aluminous firebricks slightly, due to the formation of volatile chlorides of iron, magnesium, calcium and aluminium. There was evidence of the reaction $C + SiO_2 + 2Cl_2 = CO_2 + SiCl_4$. The conversion of various oxides into chlorides by the action of chlorine at 1,000 deg. C. has also been studied. In the absence of carbon, the following is the approximate order of reactivity found:—Iron oxide > magnesia > lime > titania > zirconia > alumina > silica. More complex compounds containing these oxides, such as various silicates and spinels, are less reactive than the free constituent oxides. The rate of reaction is dependent on the previous thermal treatment of the samples, being less for materials which have been strongly calcined. When a diatomaceous earth was heated in chlorine at 1,000 deg. C., 80 per cent. of the iron and magnesium and about 12 per cent. of the aluminium and calcium in the brick were removed in the form of volatile chlorides, the refractoriness of the materials being raised from cone 17 to cone 27.

Experiments have been presented in the 30th Report upon the action of atmospheres of steam, sulphur dioxide, oxygen and mixtures of these gases on a fireclay material at 1,200 deg. C., the changes found in the physical properties being small. An account is given in the present report of similar experiments carried out on the same fireclay material at 600 deg. C., for periods up to 220 hours. The effect of atmospheres of oxygen and steam at this temperature was very small, but sulphur dioxide, mixed sulphur dioxide and oxygen, and dissociated sulphuric acid caused slight contraction, but marked increase in weight, decrease in porosity and increase in transverse strength. The chemical evidence points to the formation of sulphates of all the bases present in the fireclay, but particularly of aluminium and iron. Reheating the specimens to 1,000 deg. C. in air caused almost complete decomposition of the sulphates and was accompanied by a slight permanent expansion, of about the same order of magnitude as the contraction taking place when the sulphates are formed.

The disintegrating effect of carbon monoxide on fireclays and other refractory materials is well known. It is considered by the Committee that a rapid method of measuring the resistance of materials to disintegration by carbon monoxide would be of immediate service in the selection of refractories for plants involving exposure to this gas at temperatures ranging from 350 deg. to 650 deg. C., as the method now in use requires the exposure of specimens to the action of the gas for periods up to 200 hours. A new method is put forward, depending on the passage of carbon monoxide, saturated with water vapour at room temperature, at a rate of 1 litre an hour over 75 g. of crushed sample (−8 sieve) contained in a fused silica tube at 450 deg. C.; the carbon dioxide produced is then weighed. It is suggested that, if the increase in weight of the alkali-absorption bottles, during the four-hour period commencing 30 minutes after the temperature of 450 deg. C. has been reached, exceeds 0·1 g. or 0·13 per cent. of the weight of the sample, the product should be regarded as liable to disintegration by carbon monoxide.

The test of refractoriness under load is usually carried out by increasing the temperature under a constant load. It can be carried out, however, by what is known as the "maintained temperature" variation, in which the rectangular test piece is heated in a suitable furnace in an oxidising atmosphere under a constant load at a constant temperature for a given time; the cold test-piece is then measured, and the percentage contraction determined. A number of laboratories have co-operated in carrying out tests upon this method, using a constant load of 28 lb. per square inch, a rate of temperature rise of 10 deg. C. per minute, and a maintained temperature of 1,300 deg. C. for three hours. It was concluded that the test material was sensitive to variations in thermal treatment at about 1,300 deg. C., and that a small lack of concordance between the pyrometers used in the different laboratories could account for the variation in the results. In its present form, it is evident that the maintained-temperature test of refractoriness under load is unsuitable as a standard method for general use.

* See ENGINEERING, vol. 148, page 724 (1939).

LARGE PLATE-GLASS TANK FURNACE.—One of the largest plate-glass manufacturing units in existence is described in a recent issue of the *American Glass Review*. This, a tank furnace, forms part of a modernisation scheme instituted by the Pittsburgh Plate-Glass Company, Ford City, Pennsylvania, U.S.A. The furnace has a length of 136 ft., a width of 27 ft., and a depth of 4 ft. The capacity is 1,050 tons and the estimated annual production 18 million sq. ft. of glass.

LETTER TO THE EDITOR.

SOLVENT EXTRACTION OF OIL.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article appearing in your issue of December 20, reference is made, on page 497, to our system of recovering solvents from the air displaced from solvent extraction plants. The writer quotes from one of our publications, about 10 years old, and gives an incorrect description of the type of recovery plant we supply for this purpose. The tests to determine the distribution of the solvent losses were made at a Continental works, where approximately 100 tons of soya beans were extracted per 24 hours. These tests showed that certain losses occurred, *i.e.*, by reason of residual solvent in the extracted oil and in the extracted meal and to a lesser extent in the condensed water, and that these losses together might vary between about 38 per cent. and 70 per cent. of the total make-up of solvent required, which, in the particular plant examined, amounted to approximately 0·9 per cent. of the weight of purified seed treated.

While the proportion of the total solvent which escapes from the condenser outlets, saturating the air displaced in the operation of the plant, may vary, it will be understood that this loss can be calculated theoretically, and the amount will depend upon the temperature of the solvent-saturated air leaving the condenser. The figure quoted for this concentration, of 10·2 grams per cubic foot, is equivalent to 360 grams per cubic metre and represents the saturation concentration for the particular solvent at the temperature of the outlet.

We should like to make it clear that it would not be permissible to lead the solvent-air mixture at this concentration directly to a carbon adsorption recovery plant, particularly in the case of an inflammable solvent, but that before passing to the recovery plant the solvent-air mixture would have to be diluted with air, preferably to a concentration of between 10 grams and 20 grams per cubic metre, and precautions have to be taken to ensure that in no circumstances would a mixture be formed having a composition within the explosive range. The dilution of the solvent-air mixture has little or no influence on the recovery efficiency and possesses the advantage that the heat of adsorption of the solvent is carried away by the air. While it might be permissible and convenient when working with non-inflammable solvents to provide cooling coils in the carbon beds in the adsorbers, this is not the usual practice. Installations in which air or solvent-laden air may be used for drying and cooling the carbon, are not provided with coils.

It is correct that we should say that the financial benefit which can be obtained from the installation of a recovery plant in connection with oil-seed extraction depends to a large extent on the design of the extraction plant, but, taking a rough average of installations which we have studied, it is generally possible to recover an amount of solvent equivalent to about one-half of the total make-up of solvent. The total cost for steam, labour and power varies considerably with the size of plant and is also dependent upon the nature of the seeds extracted. This cost is usually higher than in the case of solvent recovery in other industries and may vary between 3*d*. and 6*d*. per gallon of recovered solvent.

Yours faithfully,

FOR BRITISH CARBO-NORIT UNION, LIMITED,
HUGH GRIFFITHS,
Director.

16, Queen Anne's-gate,
London, S.W.1.
December 24, 1940.

UNION PACIFIC RAILROAD MUSEUM.—We are informed that 46,280 persons, coming from all parts of the United States and from 24 other countries, visited the Union Pacific Railroad Museum at Omaha, Nebraska, during its first year. The Museum, which was opened in August, 1939, contains relics and historical exhibits connected with the development of the western States of the Union.

OBITUARY.

MR. W. CRUICKSHANK.

WE regret to record the death of Mr. W. Cruickshank, which occurred in Glasgow, on Sunday, December 27, at the age of 69. He served for many years in the engineering department of the Post Office and played a leading part in the training of the younger members of the staff.

William Cruickshank was born on August 26, 1871, and entered the engineering department of the Post Office at the age of 17, when he obtained an appointment as telegraphist at Keith. In 1901, he became a clerk in the superintending engineer's office at Manchester, while from 1903 to 1912 he was a sub-engineer in the Post Office factory at Holloway and in the designs section of the Engineer-in-Chief's office. In 1912, he was appointed assistant engineer in the same section, and during the war of 1914-18 was engaged first in the design and issue of war material of various kinds, and then as chief signals instructor of the Eastern Command. In the spring of 1919 he was responsible for installing the telephone exchange at General Headquarters of the Army of the Rhine in Cologne. He subsequently returned to the designs section and after promotion to the rank of executive engineer in 1924 was, to begin with, in charge of telegraph and constructional work at the Post Office Research Station and then in charge of research work on telegraph and telephone apparatus and systems. He held this position until his retirement in 1931.

In addition to his official work, Cruickshank was a member of the teaching staff of the Northampton Polytechnic, London, for 14 years, and lectured on telephony and telegraphy. He was also editor of the *Post Office Electrical Engineer's Journal* for 18 years, and had charge of the exhibit staged by the department at the British Empire Exhibition, Wembley, in 1924. He was elected an associate member of the Institution of Electrical Engineers in 1910 and transferred to the class of member in 1922.

MR. W. T. CALDERWOOD.

WE note with regret the death of Mr. William Tannahill Calderwood, which occurred at his home in Cathcart, Glasgow, on December 29, 1940. Mr. Calderwood, who retired some 15 years ago from the position of constructional engineer to the Electricity Department of the Corporation of Glasgow, was born in 1860. He commenced his technical education at the University of Glasgow and acted for a time as assistant to the late Lord Kelvin. Upon gaining a Whitworth Scholarship in 1885, however, he proceeded to the University of Edinburgh, where he studied mathematics and engineering. Subsequently, he became assistant manager of the Oakbank Mineral-Oil Works, near Edinburgh, but relinquished this position while still a young man and went out to South America to take up the position of manager of the Gas and Mineral-Oil Works at Taubaté, in the State of São Paulo, Brazil. After occupying this position for a number of years he returned to his native country and was made engineer in charge of the design and construction of a works for the manufacture of sodium cyanide for Messrs. Hurlet and Campsie Alum Company. Subsequently, he entered the service of the Glasgow Corporation Electricity Department and took an active part in the developments which occurred as a result of the steady growth in the utilisation of electric power. As constructional engineer he played a leading part in the erection of Dalmarnock Power Station and was also personally responsible for other important work carried out by the Corporation. Mr. Calderwood was for many years a member of the Institution of Engineers and Shipbuilders in Scotland and an associate member of the Institution of Electrical Engineers.

THE ARGENTINE OILFIELDS.—A new well on the Lunlunta oilfield, in the Province of Mendoza, Argentina, which entered into production on October 19, is giving a yield of over 200 cub. metres of oil a day. It is 2,559 metres deep.

REAR-ADMIRAL G. W. MELVILLE, U.S.N. (1841-1912).

REAR-ADMIRAL GEORGE WALLACE MELVILLE, U.S.N., the centenary of whose birth occurs to-day, was one of the founders of the modern Navy of the United States. From the time of the Civil War, 1861-65, in which he served as a junior engineer, until the later 'eighties, when he was made Engineer-in-Chief of the Navy, little interest was taken in naval affairs, and it was with difficulty that Congress was prevailed upon to grant appropriations for any men-of-war at all. The eyes of the American people were directed more towards the States of the West than towards the ocean, and the Navy was neglected. The result of this was that Chief Engineer J. W. King, who had been head of the engineering department, wrote, in 1881, in his book, *The War-ships and Navies of the World*, that "the American Navy is not at present possessed of a single armoured seagoing ship, and has strictly but few modern cruising vessels and no armaments of modern rifled guns; in these respects, at least, it differs at present from the navies of all considerable European powers." Another American naval officer, at a much later period, wrote that "by 1883 the condition of the Navy had become so bad that officers were ashamed to take their vessels into ports where the vessels of foreign nations might be encountered, so antiquated were our ships, not only in appearance, but in material of all description." The year 1883, however, marked the turn of the tide, and after that, year by year, appropriations were increased and gradually the fleet of the United States became more worthy to represent a rich and powerful nation with great maritime interests. The share that Admiral Melville had in the expansion of the fleet was far-reaching and important.

Melville was the son of Alexander Melville, whose father had emigrated from Stirling to New York in 1804. From school he passed to the Brooklyn Polytechnic, and then entered the engineering works of James Binns. The outbreak of the Civil War led him, when 20 years of age, to join the Corps of Engineers of the United States Navy. During the next four years he saw active service in many waters, on all occasions showing that courage, skill and resource for which he became known. The war over, the Navy and all its activities soon became a matter of little concern to the public, and, in the 'seventies, Melville found an outlet for his energies in participation in Polar expeditions, gaining thereby much distinction. In 1873, he was engineer of the Tigress, sent out to search for the crew of the Polaris; in 1879, he was engineer of the Jeannette, which sailed from San Francisco for the north on an expedition which lasted three years, and in 1884 he sailed in a squadron sent to the relief of the Lady Franklin Bay expedition. His heroism and endurance in the Jeannette and on the return home after the ship had sunk, gained him promotion, a Congress Gold Medal, and the freedom of New York.

The renaissance of the Navy dates from 1883, when money was voted for the three protected cruisers Chicago, Atlanta and Boston. The first of these ships had machinery the like of which has never been seen before or since. It consisted of two two-cylinder compound engines, one driving each of the two propeller shafts. The cylinders stood vertically on the bottom of the ship, with the piston rods passing through the upper heads and connected by links to a walking beam arranged athwartship. The other end of the beam was connected through similar links to the crankshaft on the opposite side of the ship. These three vessels were followed, in 1885, by the Charleston and Petrel, with compound engines, and the Newark and Yorktown with triple-expansion engines, all horizontal. These ships were still under construction when, in 1887, Melville was made head of the Bureau of Steam Engineering, and it is some measure of the state of naval engineering in America at that time, that the designs for the Charleston, and, later, for the Baltimore, were obtained from foreign sources. The year after Melville took office appro-

priations were made for 19 vessels, and, in the next ten years, both battleships and cruisers were added to the fleet. In the battleships Maine and Texas, Melville installed vertical triple-expansion engines; the cruisers New York and Brooklyn were fitted with four triple-expansion engines, driving two shafts, as in the British cruisers Blake and Blenheim, and, in the cruisers Columbia and Minneapolis triple screws were used. Though Melville was inclined to advocate the retention of the well-tried cylindrical boiler, all doubts as to the advantages of the water-tube boiler were swept away by the experiences of the Spanish-American War of 1898, when the United States abandoned its policy of isolation and became a world power. That war also destroyed, once for all, the lingering belief in the monitors of which Americans had been so proud, and the United States Navy from that time developed on parallel lines to those of European powers. In the year following the Spanish-American War, Melville was raised to the rank of Rear-Admiral, and as such he remained at the head of the engineering branch of the Navy until 1903, when he retired. Subsequently, for a few years, he was in partnership as a consultant with the Scottish engineer, John Henry Macalpine (1859-1927), and together they introduced the Melville-Macalpine floating-frame reduction gear for use in ships. His notable work in marine engineering was recognised in many ways, among the honours that fell to him being the honorary membership of the Institution of Naval Architects. He contributed several articles to the columns of ENGINEERING, and in our issue of March 3, 1905, will be found his presidential address, "Epochs in Marine Engineering," to the American Society of Mechanical Engineers. His most valuable writings, however, were his annual reports to the Secretary of the Navy, and it was in these that he recommended the establishment of an experimental station, a suggestion which was adopted during the year in which he retired. He died at Washington on March 17, 1912, at the age of 71.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

THE Council of the Institution of Electrical Engineers has decided that, under the prevailing conditions, it would be inadvisable to hold meetings of the Institution during the second half of the present session. A limited number of advance copies of papers, which in normal circumstances would have been included in the programme of meetings, however, will be available to members who contemplate the submission of written discussion for publication in the *Journal* with the author's reply. A list of these papers and the approximate dates on which advance copies will be available are given below:—"Electricity in Paper Mills," by Messrs. W. J. Mason and S. A. G. Emms (February 1); "The Design of Television Receiving Apparatus," by Mr. B. J. Edwards (February 5); "The Electricity Supply (Meters) Act, 1936—Its Legal and Technical Implications," by Mr. Alwyn Evans (February 7); "Outdoor Bushings for Transformers and Oil Circuit Breakers," by Mr. W. A. Cook (February 12); "The Future of Domestic Electrification," by Mr. P. Schiller (February 20); "The Fluctuations of Space-Charge Limited Currents in Diodes," by Dr. F. C. Williams (March 5); "The Mechanism of the Lightning Discharge and its Effect on Transmission Lines" (E.R.A. Report S/T18), by Messrs. C. E. R. Bruce and R. H. Golde (March 20); and "Subsidence Transients in Circuits Containing a Non-Linear Resistance with Reference to the Problem of Spark-Quenching," by Messrs. A. Fairweather and J. Ingham (April 24). Separate application should be made for each paper and the Council hopes that, in the interests of economy, members will apply only for those papers to the discussion of which they are likely to contribute.

A formal ordinary meeting of the Institution will be held at 12.30 p.m., on Thursday, January 30, for the purpose of carrying out a ballot in respect of the candidates whose names were suspended at the ordinary meeting held on January 2. The Council points out that under the by-laws only corporate members and associates are eligible to participate in the ballot. It is, moreover, proposed to arrange for the Kelvin Lecture, by Dr. S. Chapman, F.R.S., to be delivered at 3 p.m., on Thursday, May 8, immediately following the annual general meeting, which is to be held on that day at 2.30 p.m. Dr. Chapman will deal with the subject of "Electrical Works by Helios, or the Sun and the Ionosphere."

LABOUR NOTES.

IN July last, it will be recalled, panels of local employment committees were set up by the Ministry of Labour and National Service to inquire as to the employability of men who had been out of work for a month or longer. They were instructed to see all such men and to classify them in three categories. The results of the inquiry have now been made known by the Ministry of Labour and National Service. By the end of October last, 151,720 men—a large majority of the total number—had been seen by the panels (some of which were assisted by representatives of trades councils) and classified as follows:—Fit for immediate employment, 116,585; likely to be suitable after a trial period or reconditioning, 3,006; unsuitable for ordinary employment, 37,418. Some men were included, the Ministry says, in more than one of the three categories, and panels did not always follow a uniform line in regard to men fit only for light occupation. As will be noted, of the men seen over 24 per cent. are classified as virtually unemployable in ordinary circumstances. Nevertheless, it is recorded, a considerable number of these men did get employment during the three months following the beginning of the inquiry.

A count on October 28 of the men seen by the panels, and still on the register, showed the number fit for immediate employment to be 61,869—a reduction of 54,700, and the number unsuitable for ordinary employment to be 29,360—a reduction of over 8,000. By November 11, this number had fallen to 24,845. By then, more than 12,500 "unemployables" had got work. A small survey of nearly 200 cases of such men who had gone off the register showed that 50 per cent. had been placed or had found work.

In a further review which is to take place, the scope of the inquiry is to be extended to include men who have had less than an aggregate of four weeks' employment in the preceding four months. Men placed in the "unsuitable" category will be further sub-divided in order to show those who are suitable in every respect for light work. It is hoped that such men can be fitted into employment to release men whose services can be better utilised in the war effort in some other work. Panels are being asked to consider specially the question of mobility and the possibility of suggesting men for training. Under the expanded programme, it is stated, a continuous flow of recruits is required. The Ministry states that it is convinced that applicants have considerably benefited by the opportunities of discussing their prospects with the panels. Not only, it adds, have the panels interested themselves in placing individuals, but the men themselves have been stimulated to further efforts.

In November, the number of unemployed members of the United Patternmakers' Association decreased from 115 to 92, and the number of members in receipt of sick benefit from 230 to 214. Superannuated members increased from 668 to 674. The membership of the Association is now 12,620; in the previous month it was 12,600. "We are approaching very near," Mr. Findlay, the general secretary, says, "to the record figure of the Association's membership of 12,748 in 1921."

The text of an agreement on the subject of wages in certain areas, between the Shipbuilding Employers' Federation and the United Patternmakers' Association, is given in the latest issue of the trade union's official report. It is mutually agreed that "(1) The plain time rates of patternmakers employed on pattern-making work in the Bristol Channel, Bristol and District, Cowes, Falmouth, Manchester, Mersey and South Coast districts shall be 78*s.* per week on new shipbuilding work, composed of 51*s.* basis rate plus 27*s.* bonus, and on ship-repairing work 81*s.* per week, composed of 51*s.* basis rate plus 27*s.* bonus plus 3*s.* per week repair allowance. (2) In addition to the plain time rates in clause (1), patternmakers who are not already receiving extra remuneration by way of compensatory or lieu rates or earnings from a system of payment by results shall, in accordance with the terms of the agreement of July 3, 1940, between the Engineering and Allied Employers' National Federation and the United Patternmakers' Association, be paid an additional payment on both new and repair work of 5*s.* 9*d.* per week. (3) Extra payments and allowances calculated on plain-time rates or on plain-time basis rates, as provided in existing local agreements, shall continue to be paid in accordance with these agreements, but on the appropriate revised rates contained in clause (1). (4) In accordance with existing agreements and practices, wages of patternmakers employed by shipbuilding and ship-repairing firms in the districts mentioned in clause (1) shall in future follow national fluctuations in the engineering industry. (5) In accordance with the terms of the agreement of July 3, 1940, between the Engineering and Allied Employers' National Federation and the United Patternmakers' Association, the additional payment in clause (2) shall apply only during the war-time emergency and for the period thereof." The agreement operated from the first full pay week after December 5, 1940.

It is understood that, as a result of a conference between the Minister of Labour and National Service and representatives of the engineering employers and engineering trade unions, certain suggestions relating to armaments production and man power have been embodied in a private memorandum by Mr. Bevin and circulated to the trade unions and, through the federation, to the employers' district associations. Mr. Bevin, it is stated, will meet the employers and the unions again later this month. He hopes that industry will itself be able to deal effectively with its own problems.

Under an agreement to which the Italian Fascist Confederation of Manufacturers and the Fascist Confederation of Industrial Workers are parties, the employers have the right to make up for hours of work lost through air-raid warnings by extra hours paid for at normal rates. The extra work must be carried out within sixty days. If the making up of lost time proves impracticable in whole or in part, the workers concerned will receive the normal daily wage if the suspension of work does not exceed 30 minutes; if it exceeds 30 minutes, time in excess of that limit will be paid at half the normal rate.

According to a recent issue of the *Review* of the United States Department of Labour, the present German Government has set up lower labour standards for non-German than for German workers. How far the two standards differ is indicated, the writer says, by a list of rules issued in May last by the State Labour Trustee of East Prussia, fixing the conditions for farm hands in the District of Zichenau, Province of Suwalki, District of Soldau, and Province of Reidenburg. The term of the employment contract is one year. The length of the working day varies in accordance with the seasons from 6½ hours in winter to 12 hours in summer for non-German farm hands and from 6½ hours in winter to 10½ hours in summer for German farm hands. These are actual hours of work; an hour and a half in winter and two hours in summer are allowed for lunch.

The money wages of married German farm hands are, under the rules, 15 marks per month in winter and 22 marks in summer. Married non-German farm hands in Suwalki Province receive monthly, in money wages, 6 marks in winter and 9 marks in summer. In Zichenau and Soldau districts they receive 8 marks in winter and 12 marks in summer. Payment per hour for overtime, and work on Sundays and holidays is approximately twice as high for German as for non-German hands. The married farm hands receive an allowance of 28 cwt. of grain in wheat, peas, barley, rye and mixed grain, per annum. Married farm hands have free housing and barns for their animals. For heating, non-German farm hands receive 60 cwt., and German farm hands 70 cwt., of soft or brown coal briquettes.

A detailed survey of wages and hours in the American iron and steel industry was made by the Bureau of Labour Statistics at Washington in the spring of 1938. It covered a total of 81,217 wage earners in 276 iron and steel plants. The investigation showed that in April, 1938, workers in the industry earned an average of 83·9 cents an hour. All but 10·4 per cent. earned at least 62·5 cents an hour and over one-half (51·2 per cent.) earned at least 77·5 cents an hour. Although 10·4 per cent. of the workers averaged less than 62·5 cents an hour, less than 1 per cent. (0·4) had earnings under 40 cents an hour and less than one-tenth of 1 per cent. had earnings under 30 cents an hour. It is evident, therefore, the Bureau experts who carried out the survey say, that only very minor adjustments of the wage structure were necessary to meet the minimum wage requirements of the Fair Labour Standards Act. Moreover, they add, on the basis of the 1938 wage structure, it would be necessary to increase the wages of only 0·4 per cent. of the workers in order to comply with the highest minimum that can be set under the Act—namely, 40 cents an hour. In April, 1938, American iron and steel workers were employed an average of 28·5 hours a week and their average weekly earnings amounted to 23·96 dols.

BRITISH IMPORTS FROM THE UNITED STATES.—Exports from the United States to Great Britain during the first eight months of 1940 had a total value of 592 million dols., which was an increase of 91 per cent. over the figure for January to August, 1939.

THE PHYSICS OF STEAM GENERATION.*

By R. F. DAVIS, M.Sc. (Eng.)

(*Concluded from page* 20.)

SOME authorities (Stumpner, 1936) have attributed the carry-over of water drops in boiler steam to the bursting of the steam bubble domes into fragments; but failure of a liquid film does not take place in this manner. Fig. 8 shows frames from a cinematograph film, taken at 1,200 frames per second, of the rupture of a soap bubble (Edgerton, Germeshausen, and Grier, 1936). Even when torn by the impact of a pellet, failure takes place not by rupture into fragments, but by a progressive opening out of the initial perforation. It can be shown that the rate of disruption must be constant, and according to Lawrence (1929) in a soap bubble it takes place at 3,200 cm. per second. Due to the more rapid thinning at the highest part of a bubble dome, disruption will commence at this point, spreading outwardly and presumably without creating drops; nevertheless, when floating bubbles burst, drops of liquid are ejected under certain conditions, and, depending on the size of the bubbles producing them, some are projected to a considerable height.

If drops are projected, it is comparatively easy to see them rising and falling above the free water level; they occur not only in boiling, but also in effervescence and with the release of small air bubbles. It is not recorded, however, whether the mechanism of their projection has ever been observed, although a similar action is depicted in the frames shown in Fig. 9, opposite, reproduced from a high-speed cinematograph film (Edgerton and others, 1939) of a drop of milk falling into milk in a container. The drop creates a depression in the milk surrounded by an elevated rim of liquid, similar to the depression and rim in a small floating bubble, immediately after failure of the dome. Subsequently the rim sinks, and simultaneously the centre of the depression rises. Due to the momentum of the inflowing liquid, it throws up a spout from the centre of the depression, the tip of which necks off, under the action of surface tension, into separate drops.

If the foregoing interpretation of the mechanism of the disruption of a floating bubble is correct, it would follow that only small bubbles would eject drops, because, as indicated by Fig. 6, page 18, *ante*, large bubbles do not depress the inner liquid level sufficiently, in proportion to their size, to cause the centre of the depression to rise appreciably on release of the pressure inside the bubble when it disrupts. Craven and Stuhlman (1931), studying effervescence, found that, under atmospheric conditions, bubbles having diameters up to 1·6 mm. projected three drops, while those having diameters of between 1·6 mm. and 2·0 mm. projected only two drops. The author's own observations indicate that the first drop may rise to a height of about 10 cm., but the second only rises 2 cm. to 3 cm. above the free water level.

There is, no doubt, some relationship connecting the size of the drops, and the height to which they are projected, with the size of the bubble producing them and the physical properties of the liquid; but the mathematical solution of the problem presents many difficulties. It is evident from Fig. 9 that the maximum height to which the centre of the depression, which may be taken as representing the bottom of a bubble, eventually rises is much greater than the mean height of the total mass of moving liquid; it follows then that the height to which necked-off drops will rise above the free water level will be a function of some considerable multiple of the mean velocity of the total mass. Other conditions remaining constant, and considering only surface tension forces, the height to which the liquid is projected is inversely proportional to the fourth power of the radius of the depression, confirming the observation that small bubbles are much more effective in projecting drops of liquid than large bubbles. This fact has an important bearing on steam contamination.

In a pure liquid, the film of liquid forming the bubble dome thins very rapidly, and either disrupts before other bubbles arrive, or is hastened in its collapse by the arrival of other bubbles, since it is inherently unstable and unable to accommodate itself to changes in shape. The rate of thinning decreases with increase in viscosity of the liquid, and also with increase in the concentration of adsorbed salts. The action of the latter is due to the osmotic pressure set up between the two surfaces of the film, which opposes the squeezing action caused by the excess vapour pressure inside the bubble dome. Concentration of salts and increase in viscosity do not endow the bubble film with plasticity; this quality depending on the presence of finely divided solids. If the film contains a sufficient number of solid particles held together by the liquid, each particle will be capable of some relative movement, the liquid film acting as a link between them; the film as a whole is thus more capable of adjusting itself to slight deformation without consequent failure. Very fine particles which form colloid solutions produce a highly viscous layer of adsorbed material in the film, giving it both plasticity and stability. Steam bubbles in which the liquid film is stabilised either by particles of solid matter, or matter in the colloidal state, may remain at the free water level long enough for other bubbles to arrive and collect around them without immediately collapsing or coalescing, and thus form a layer of relatively stable foam. The depth of the foam layer will depend on the rate of thinning of the upper film relative to the rate of arrival of fresh bubbles from below.

Steam Contamination.—In modern steam generating plants steam contamination from entrained moisture and solids sometimes causes persistent and recurrent trouble, often unexpectedly and inexplicably. Such contamination causes loss in thermal efficiency, since moisture lowers the steam temperature; in quantity, it may also be responsible for direct mechanical damage to the turbine. Salts in the moisture deposited on the turbine blades will reduce the mechanical efficiency of the turbine; salt deposits occurring in the superheater tubes (see Fig. 10, opposite) may cause overheating of the metal, culminating in burst tubes. The solids deposited by carry-over are mostly soluble, chiefly sodium hydroxide, removable by continual washing out with water. In some cases sodium silicate is also carried over and forms an impervious layer of silica not so easily removed. (Tray, 1938.)

It is important to distinguish steam contamination arising from mechanical priming or from other causes of a more physical nature. A frequent cause of mechanical priming is high water-level, characterised by the entrainment of slugs of water in the steam. High water-level is usually associated with sudden changes in steam demand. A sudden increase in demand may result in what is known as "swelling." If the demand momentarily exceeds the corresponding rate of heat absorption, the boiler pressure drops, and the water is then substantially superheated with respect to the vapour in the migrating steam bubbles. The rate of growth of the migrating steam bubbles will be increased, and the resulting increase in volume of the circulating mixture will temporarily raise the water level. A temporary or oscillating high water-level may be caused by local reversal of circulation during starting-up, or when the feed is curtailed. If the rate of flow of the water in heated down-take tubes is very nearly the same as the terminal velocity of the steam bubbles tending to rise, so much steam will, in time, collect in the tube that the effective static head of the mixture may become less than that in the risers, and reversal of flow take place. Again, if the evaporation of the water in a heated downtake tube is prevented by entry of cold feed, curtailment of the feed may result in the evolution of steam in the tube, with reduction of the static head and possible reversal of circulation. There is a great deal to be said in favour of the practice of unheated downtake tubes, especially with high pressures.

Suspended solids can stabilise a foam, though under certain conditions they have little or no effect. Foulk (1936) made laboratory experiments at 250 lb. per square inch and found that much depended on the mode of formation of the solids; thus, calcium carbonate varied in its effect according to the method of precipitation. An explanation of Foulk's experience with these precipitates may be that their physical condition was different in each case. Some solids in particle form will float on the surface of a liquid having a lower specific gravity than the solid. For a solid to float thus, the contact angle must be greater than zero, and it must also be possible to vary the angle by hysteresis; with an absolutely constant angle a slight tilt would cause the particle to sink. Where particles float at the surface, observation reveals that the surface of the liquid at the point of suspension of each particle is bent down to form a dimple or depression, at the bottom of which the particle hangs suspended in the liquid. The foam-stabilising power of precipitated particles of boiler sludge, which are mechanically suspended and circulated in the boiler water, will depend on whether the particles are smaller than a certain limiting size, which, in turn, is a function of the operating pressure, the density of the particles, and the contact angle. "Wettable" solids having zero contact angle will not float at the surface nor provide a stabilising scum for foam formation. Some substances will, however, float when scattered on water in a dry condition, but, due to the hysteresis of the contact angle, will no longer float after being submerged; the lesser contact angle is, therefore, the criterion for boiler-water precipitates. These precipitates consist mainly of calcium carbonate or calcium phosphates, depending on the chemical treatment. It would seem that the largest sludge particles capable of floating at the free water surface at ordinary boiler pressures are of the order of 0·5 mm. in thickness.

The question arises, how are the particles conveyed from the interior of the boiler water to the free water surface? The steam bubbles in moving through the water collect widely dispersed particles, in the same way that air bubbles do in the froth flotation of mineral ores, whereby selected minerals are separated by this process, according to their contact angles. Providing the particles have a finite contact angle, that is, they are not "wettable," they will adhere to the bubbles by the same mechanism that enables them to float at the free water surface. As each bubble collapses at the free water level, it deposits its load of particles, which ultimately form a scum; when foaming takes place, this scum is deposited just above the water level on the walls of the boiler drum, and sometimes in the steam outlets. The mechanics of flotation has been dealt with in detail by Wark (1933); its analysis is very complicated, but it is evident that the contact angle is in this case the limiting factor, since from considerations of buoyancy alone the steam bubbles could transport particles nearly twice the size limited by floatability.

Particles of calcium-carbonate sludge which are larger than the limiting size referred to above will not contribute to form a scum, and will have no influence on the foaming properties of the boiler water. Coarse granular material generally has no effect on foaming, but the finer the precipitate the more likely it is to cause foaming. The solids, in precipitating out from the boiler water, must pass through a stage

* Paper entitled "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination," read before the Institution of Mechanical Engineers, on Friday, December 13, 1940. Abridged.

PHYSICAL ASPECTS OF STEAM GENERATION.

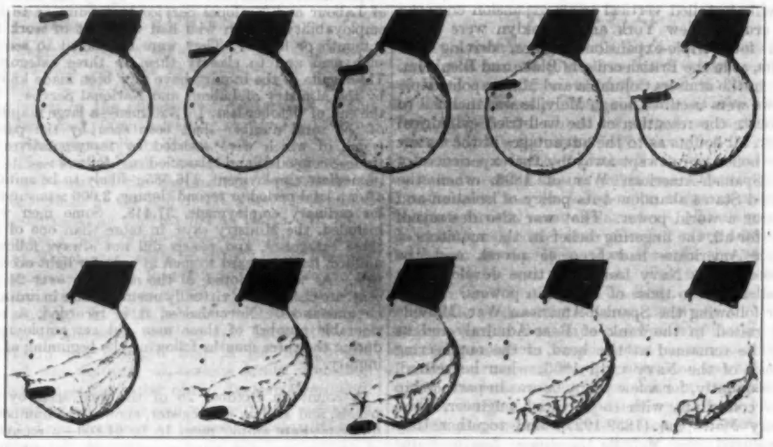

FIG. 8. COLLAPSING SOAP BUBBLE.

PHYSICAL ASPECT OF STEAM GENERATION.

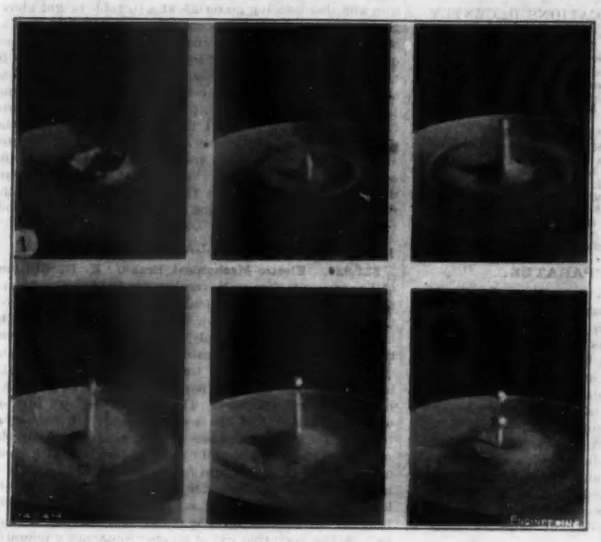

FIG. 9. DROP OF MILK FALLING INTO MILK.

FIG. 10. CHOKED SUPERHEATER-TUBE BEND.

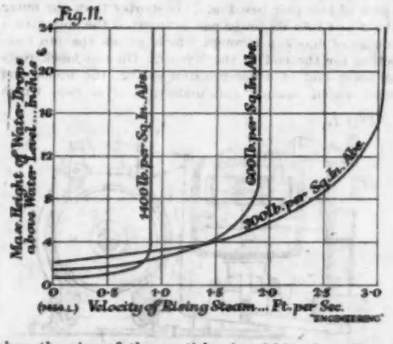
Fig.11.
Max. Height of Water Drops above Water Level ... Inches
1400 lb. per Sq. In. Abs.
600 lb. per Sq. In. Abs.
200 lb. per Sq. In. Abs.
Velocity of Rising Steam ... Ft. per Sec.
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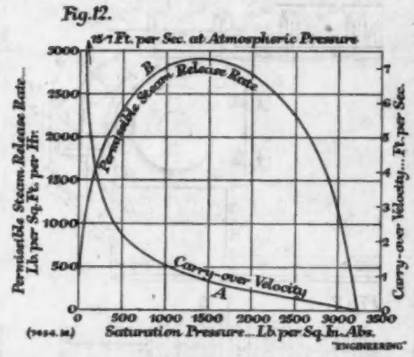
Fig.12.
15·7 Ft. per Sec. at Atmospheric Pressure
Permissible Steam Release Rate
Carry-over Velocity
Permissible Steam Release Rate ... Lb per Sq. Ft. per Hr.
Carry-over Velocity ... Ft. per Sec.
Saturation Pressure ... Lb per Sq. In. Abs.
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when the size of the particles is within the colloidal region, which stabilises the bubble films; but unless the boiler water contains a peptising agent, the particles will continue to grow in size and may even coalesce or flocculate into a true precipitate, in which case the colloidal stage will only be transient and will have very little influence upon the steaming properties of the water. Unfortunately, boiler water always contains a large proportion of caustic alkali (NaOH), which is a very effective peptising agent.

That sodium hydroxide, and possibly also sodium phosphate, have some effect on the foaming qualities of boiler water is possible, but lack of understanding of its true function has led to confusion of the evidence. It was shown, for instance, that a solution of sodium hydroxide up to 50,000 parts per million did not foam. Later experiments showed that no foaming occurred with high concentration of sodium salts unless suspended matter was present in the water (Powell, 1937). No doubt some of the suspended matter was in this case converted to the colloidal state. According to Niehaus (Stumpner, 1936), colloids in boiler water lead to persistent foaming, a degree of dispersion of the order of 0·1 μ diameter having the maximum effect. The proportion of sodium hydroxide to total solids has been found to be an important factor in foaming. Caustic alkali also decomposes organic materials, such as oil, sewage, and humic matter, into colloidal decomposition products. Boiler water contaminated in this manner is, therefore, very liable to foam.

Evidently, methods to be adopted to prevent foaming must in each case depend on the specific cause, which is not often easy to elucidate. As a general rule, it is advisable, if foaming occurs, to reduce the concentration of the dissolved solids in the boiler water, and at the same time the alkalinity should not be allowed to exceed 15 per cent. of the total dissolved solids then remaining. If a continuous blow-down is needed to reduce the concentration, it should be fitted to the drum at which maximum effective concentration occurs; for instance, in a three-drum boiler this would be at the upper front drum. The precipitated solids, which settle out in the lower drums and headers, obviously cannot contribute to the foamability of the water, and need only be cleared out intermittently. The presence in the boiler water of substances having coagulating properties, such as aluminium hydrate and tannins, has been observed to reduce foaming. Sodium aluminate has also been successfully used as a coagulant. It is also recorded (Matthews, 1938) that the addition of castor oil to boiler water can prevent foaming. Its action is obscure; it may have some coagulating action, or it may become adsorbed on the surfaces of the suspended particles, resulting in reduction of the contact angle. Where organic matter is the original cause of foaming, Tray recommends the addition of a small quantity of activated carbon, fed to the boiler internally, together with sufficient iron as hydrous ferrous oxide to coagulate the carbon.

Small steam bubbles, disrupting at the water level, project minute drops of water into the steam space. The height to which the drops rise above the water level depends not only upon their velocity of projection, but also on the resistance of the rising vapour and its velocity. The curves of Fig. 11 have been prepared to show the effect of the velocity of the released steam on the height of projection of the water drops, at three different pressures. At low pressures an increase in the rate of steam release has an appreciable effect upon the height to which the drops rise; this is confirmed by Vorkauf's conclusions that at low pressures the height of the steam space has considerable influence on the wetness of the steam. Obviously, if the drops are projected so high that they enter or approach the steam outlets (or any other region where the vertical component of the steam velocity exceeds the terminal velocity of the drops), the drops will be entrained with the steam. Vorkauf concluded from his experiments, carried out at comparatively low pressures, that both the height of the steam space and the area of steam release were effective in controlling the wetness of the steam, and deduced therefrom that the steam space volume was the important factor. Actually, the area of release and the height are two separate factors, one of which—the height—becomes decreasingly important as the saturation pressure increases. This is evident from the curves for 600 lb. per square inch and 1,400 lb. per square inch, Fig. 11; at the latter pressure the water drops probably do not rise more than about 2 in. above the water level, but carry-over will occur much more suddenly and at a much lower steam velocity. It was discovered by Vorkauf, and since frequently observed in practice, that true carry-over occurs suddenly, when the evaporation has reached a certain definite rating; the nature of the curves in Fig. 11 indicate that this is to be expected.

The relationship between the probable carry-over velocity of the steam and the operating pressure is shown in Fig. 12. The curve of permissible rating allows for a factor of safety of 4 on the calculated carry-over velocity, to allow for inaccuracies in the assumptions made and variation in the local, as compared with the calculated, average rate of steam release. The most objectionable feature of carry-over is the deposition of the dissolved salts from the boiler water, when the drops projected by the disrupting steam bubbles, which are carried over with the steam, eventually evaporate. The water drops partially evaporate during superheating of the steam, some of the solids then forming deposits in the superheater tubes (see Fig. 10), while the remainder may pass on and cause deposits on the turbine blades. A comparatively small amount of carry-over can cause appreciable trouble at the turbine; with boiler water containing only a few hundred parts per million of solids, several pounds of deposit may form during a day's run, even if there is only 0·5 per cent. moisture in the steam. The chemical which causes the main difficulty is sodium hydroxide, the concentration of which varies with the temperature and steam pressure. According to Straub's investigations, sodium hydroxide solution, at the steam temperatures and pressures used in modern plants, may contain from 10 per cent. to 20 per cent. moisture, resulting in a semi-fluid sticky solution, which will adhere to metal surfaces, accompanied by some of the salt residues having high fusion temperatures, such as sodium chloride, sodium carbonate, and sodium sulphate. Straub suggested that the adhesion of the sodium hydroxide might be prevented by the addition to the boiler water of more solids of a powdery nature, or by adding certain organic compounds to the boiler water; but either of these methods may lead to further trouble by causing foaming. An alternative means is to remove the salts from the moisture, or to remove the moisture from the steam.

The position of the steam inlets to the drum has a great influence on the steam quality. Vorkauf found that reduction in the wetness occurred if the steam inlets of riser tubes discharged above the water level, instead of below it; and in cases of foaming, it had the added effect of depressing the foam layer. The advantages of this construction may depend to some extent on the physical qualities of the steam and water mixture discharging from the riser tube, which again may vary with the rate of circulation and the chemica

composition of the boiler water. Only those tubes which are expected to discharge a mixture containing a very large proportion of steam should have their outlets above the water level. From Brooks and Badger's experiments it can be inferred that if the proportion of steam in the mixture leaving a riser tube is relatively small, then the mixture will discharge above the water level as a froth, and if there are sufficient dissolved salts in the water, there is no doubt that a froth discharge will tend to persist with still greater proportions of steam in the mixture. If, on the other hand, the boiler water has a low concentration of solids, as the proportion of steam increases the bubbles will coalesce and the discharge will take place in alternate slugs of water and vapour.

To produce reasonably dry steam, the steam should be separated from the water in the boiler drums. Vorkauf has shown that proper control at this stage can exert considerable improvement in the quality of the steam. The arrangement of the internal baffles, fittings, and those tubes entering the drums should be designed as may best dry the steam. The steam outlet must be as high as possible above the water level, and above the least disturbed portion of the water surface; and it should be protected against the direct ingress of projected water drops or spray. The carry-over of small drops can be diminished by allowing them the maximum opportunity to separate out: (*a*) by gravity; (*b*) by centrifugal force; and (*c*) by impingement on baffle plates. Steam which has once had the initial moisture removed should not be passed subsequently through a zone of greater wetness.

The application of these principles to steam drying can be as diverse as the various types of boiler. There are also many special designs of centrifugal and baffle-type driers in use, and descriptions of these have appeared elsewhere. At high pressures, the centrifugal method of separation becomes increasingly less effective, because the water drops are smaller and the difference in density of the steam and water is less. Although other methods of separation have been suggested, such as electric glow discharge, and ultrasonics, the alternative principle has lately been adopted, more especially in America, of washing the steam by the incoming feed water. Any moisture consequently entrained in the steam by washing then has a much lower concentration of solids than the boiler water. Steam washing is achieved either by passing the steam through baffles wetted by the feed water, or by bubbling the steam through the feed water, or, in another type, by spraying the feed water into the steam; subsequently, the steam is passed through some form of dryer to remove the excess of moisture, the whole process taking place in the main steam and water drum.

Conclusions.—Theoretically, the physical properties of the boiler water may profoundly affect its steaming qualities, changes in which must be expected at higher operating pressures. Normally, evaporation at the heating surface takes place by nuclear boiling, and with increase in the operating pressure the size of the bubbles generated becomes smaller. The average size of the steam bubbles reaching the free water level at low pressures is much greater than those arriving under high pressures, unless these coalesce into larger units. The size of the surface bubbles will not be uniform, owing to differences in nature and slope of the generating surfaces, rates of circulation in the tubes, and periods of growth during migration. A predominance of large bubbles reduces the probability of water drops being ejected into the steam space; small bubbles are more likely to contribute to the carry-over of moisture in the steam. The more dissolved solids in the water, the less the tendency for the bubbles to coalesce; with a low concentration of dissolved solids small bubbles more readily coalesce and form larger units which are not so likely to project water drops into the steam space upon disruption at the water level; they also induce a faster rate of circulation. To preserve a reasonable purity of steam, a concentration of solids in the boiler water, possibly satisfactory at low pressures, cannot be tolerated at high pressures, from stabilisation of the undesirable small bubbles formed at high pressures.

Dissolved solids in the water do not appreciably affect surface tension, but influence stabilisation of bubbles by adsorption at the bubble interfaces. Persistent foam is due to the presence of suspended matter, principally in the colloidal state. To minimise this stabilisation of foam the proportion of caustic alkalinity must be kept low and organic matter practically excluded from boiler water. In a high-pressure boiler, purity of the steam may be partly ensured by careful design of the internal baffles and fittings. In operation, the steaming properties of the boiler water depend almost entirely on the nature of the feed water and the careful control of its chemical treatment, both as regards the purely chemical changes and the physical and chemico-physical changes. Existing chemical treatments to protect a boiler are not usually designed to prevent steam contamination—they may even be the cause of it.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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FURNACE APPARATUS.

526,371. Carrier-Bar Stoker. John Thompson (Wolverhampton), Limited, of Wolverhampton, and J. T. Ruddock, of Wolverhampton. (6 *Figs.*) March 14, 1939.—A defect of carrier-bar stokers is that consecutive individual grid links separate as they pass round the end drums or sprockets, so that ash falls into the interior at the forward end of the stoker where it eventually causes trouble. The surface of the stoker illustrated is composed of transverse grids of links 1, 1*a*, 1*b*, 1*c*, etc., running lengthwise. The links of each row are fitted side by side upon a carrier bar 2 with a bulb-shaped head, these bars being attached to driving chains 3, the links of which are pivoted together approximately below the rear end of the respective grid. Each grid is composed of a large number of ordinary links 6,

Fig.1.

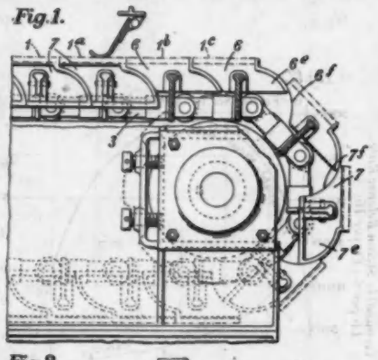
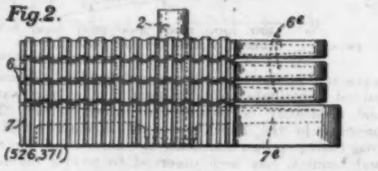


Fig.2.



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between two locating links 7 at the ends of the carrier bar. Each ordinary link is formed with prismatic serrations along its top and both top edges, the latter being alternated so that the crests on one link engage to some extent in the troughs of adjacent links (Fig. 2). The end links 7 are generally similar, except that they are thicker and deeper, and are secured to the carrier bar 2 by a cotter pin. In the effective flight, the grids abut directly against each other to form a continuous grid surface. To avoid the separation of the ends of the link, when they pass round the driving sprockets, each grid is formed with a tail portion 6*e* or 7*e* springing from below the grid surface, and has the front part of its flange correspondingly cut away at 6*f* or 7*f*. Hence, when a grid passes round a sprocket, the tails 6*e*, 7*e* rock smoothly out of the recesses 6*f*, 7*f* of the links of the following grid, a slight overlap being still maintained, and thus effectively bridging the gap between them. (*Accepted September* 17, 1940.)

MINING, METALLURGY, ETC.

518,762. Pig-Iron Manufacture. H. A. Brassert and Company, Limited, of London, H. A. Brassert, and T. P. Colclough, of London. June 1, 1938.—The invention is a process for producing pig iron in a blast-furnace, in which an acid slag is produced and low blast temperatures are used. With acid burdened furnaces using carbonate or other types of ores, less fuel is required to smelt the ores if lower wind temperatures are used; for example, at temperatures of 700 deg. F. or less, relatively heavy burdens may be carried, and relatively low blast pressures and blast volumes (per ton of pig iron produced) are required. For optimum conditions of working with acid burdening, the whole of the raw material charged into the furnace, except some of the coke, must be reduced to the molten state before reaching the combustion zone at the tuyeres. The effect of using lower blast temperatures is to maintain the fusion zone of the reduced iron and slag-forming materials at a suitable height above the tuyeres, resulting in generally smoother descent of the burden, lower coke consumption and increased output. Figures obtained from a furnace which was in continuous operation under carefully controlled conditions showed that, by progressively reducing the blast temperature from 1,161 deg. F. to 690 deg. F., the coke rate fell from 3,346 lb. to 2,424 lb. per ton of iron, and the daily production of pig rose from 217 tons to 402 tons. During this test the blast volume increased from 28,400 cub. ft. to 40,700 cub. ft. per minute and the blast pressure decreased from 18·8 lb. to 15·7 lb. per square inch, the figures given being averages taken over the test period. (*Accepted March* 7, 1940.)

MISCELLANEOUS.

521,825. Electro-Mechanical Brake. E. R. Elliston, of London. (4 *Figs.*) November 29, 1938.—The invention is an electro-mechanical brake, which provides for the immediate application, on de-energisation of the magnet, of a fraction only of the maximum braking torque, the rate of increase of braking torque being variable. This obviates the excessive strain usually imposed on the braking parts, and leads to increased life of the brake linings. The brake shoes are pivoted on the bedplate *f* of the assembly, and are connected by a load-equalising linkage *i*, which is connected to the upper end of a vertical pull rod *s*. A lever *t*, which rocks about a horizontal fulcrum on the bedplate, has arms of unequal length, the shorter arm being pinned to the lower end of the pull rod *s*. On the other side of the fulcrum the rocking lever is connected, through a short link, to the operating rod of an electromagnet *y* mounted in a housing bolted to the bedplate. The end of the longer arm of the lever *t* embraces the lower end of one of a pair of vertical telescopic tubes 1, 2. The inner tube 1 of this pair (see Fig. 2) is shorter than the outer tube 2 and into its lower end is inserted the spigot of a shouldered block 3 through which passes the pin connection for the end of the lever *t*. On the block rests the lower end of a compression spring, the upper end being seated against the underside of a cap, which

Fig.1.

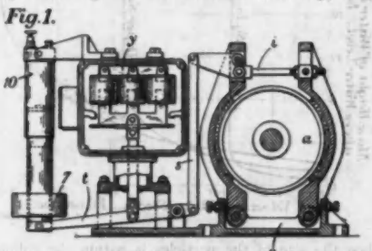

Fig.2.

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closes the upper end of the outer tube 2. The outer tube also carries a main brake weight 7 and can slide over the inner tube, compressing the spring, until it rests upon the shoulder of the block. The cap at the upper end of the outer tube carries a packing washer 9 and forms a piston which slides within a dashpot cylinder 10, the upper end of which is secured to a bracket on the casing of the electromagnet. A ball valve allows the piston 9 to travel freely upwards, but retards its downward travel. An adjustable needle valve allows of fine control of the rate of descent of the piston. To apply the brake, the current is cut off, whereupon the longer arm of the lever *t* immediately falls under the combined action of the spring and the weight of the magnet armature until the brake shoes contact with the brake drum *a*. They then apply a torque due to the weight of the several parts and the load, if any, exerted by the compression spring, the latter being pre-determined according to the particular requirements. During the brief interval occupied by this operation, the weight 7 does not move appreciably, due to the suction on the upper side of the piston 9. As, however, air leaks into the cylinder through the needle valve, the weight 7 begins to fall, and in doing so compresses the spring, thus automatically increasing the load on the brake, until finally the weight is arrested by contact with the shoulder of the block 3. The full braking load is then applied to the brake shoes. In this apparatus the electromagnet has to lift a constant load which is fixed by the manufacturer, and there is no provision for the adjustment of this load. It is thus impossible for an unskilled operator to overload the electromagnet. (*Accepted May* 31, 1940.)